LUST LTi DRiVES

# ServoOne

## Application Manual

Description of
Base Software

## ServoOne High-performance drives

The modularity of the ServoOne guarantees you optimum integration into the machine process. Communication with the machine controller can be routed via a high-speed field bus system or via the distributed programmable Motion Control intelligence in the drive controller.

## ServoOne Application Manual

ID no.: 1100.22B.1-00

Date: 03/2009

Applicable as from firmware version: V1.35

## We reserve the right to make technical changes.

The content of this Application Manual was compiled with the greatest care and attention, and based on the latest information available to us.

We should nevertheless point out that this document cannot always be updated in line with ongoing technical developments in our products.

Information and specifications may be subject to change at any time. Please visit www.lt-i.com for details of the latest versions.

# Overview

Since the drive controller software offers a wide range of functions, including the facility to interface different field buses, the documentation is spread across a number of individual documents.

## Systematics of the ServoOne documentation

| Document | Contents | Description |
|---|---|---|
| Operation Manual | Device mounting, installation, safety, specification | Hardware |
| Application manuals | Function description | Base software |
| CANopen/EtherCAT User Manual | Description and parameter-setting of the ServoOne on the CANopen/EtherCAT field bus system | Hardware and software of field bus version |
| SERCOS User Manual | Description and parameter-setting of the ServoOne on the SERCOS II field bus system | Hardware and software of field bus version |
| PROFIBUS-DPV User Manual | Description and parameter-setting of the ServoOne on the Profibus-DPV field bus system | Hardware and software of field bus version |
| Parameter Description | Short description of all parameters | Base software |

## How do I read the documents?

First be sure to read the Operation Manual, so as to install the device correctly.

Attention: Disregarding the safety notes during installation and operation can cause damage to the device and danger to the life of operating personnel.

**The layout of the sections of this Application Manual and the order of subject areas in the DriveManager follow the chronological sequence of an initial commissioning procedure.**

For basic configuration and operation of the motor you should follow the descriptions in the chapters of this Application Manual. If you intend to utilize further internal functions of the drive, such as digital or analog I/Os, you should read the corresponding chapters in this documentation. Here you also receive information concerning errors and warnings.

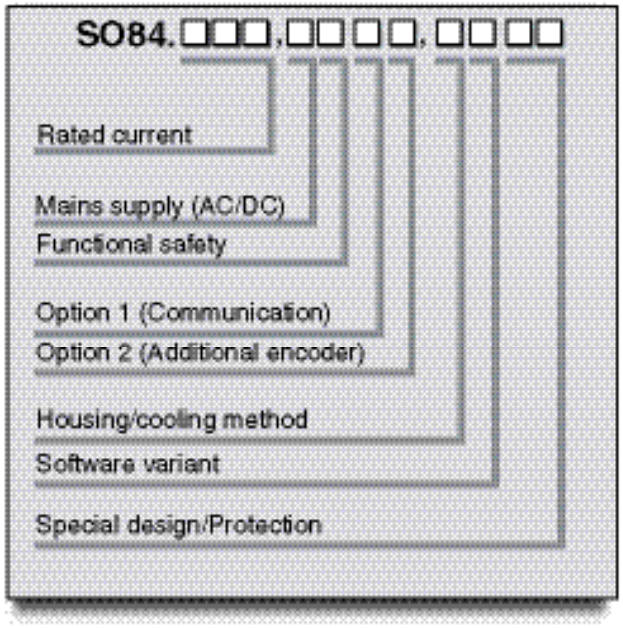
If you use a field bus option board to control a controller, please use the relevant separate bus documentation.

Attention: When working with the ServoOne please always use a DriveManager version DM 5.X.

We wish you much pleasure and success working with this device!

## Order code

The order designation provides information on the configuration variant of the servo-controller supplied to you.  For details on the order code refer to the ServoOne Order Catalogue.




## Pictograms

To provide clear guidance, this Application Manual uses pictograms. Their meanings are set out in the following table. The pictograms always have the same meanings, even where they are placed without text, such as next to a connection diagram.

| | |
|---|---|
| | Important! Misoperation may result in damage to the drive or malfunctions. |
| | Danger from electrical tension! Improper behaviour may endanger human life. |
| | Danger from rotating parts! Drive may start up automatically. |
| | Note: Useful information |

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# 1. Power stage

## 1.1 Setting the power stage parameters

The ServoOne can be operated with different voltages and switching frequencies for the power stage. To operate the controller generally, the power stage must be adapted to the local voltage conditions. A combination of mains voltage and matching power stage switching frequency is offered for this.

DM5 setup screen

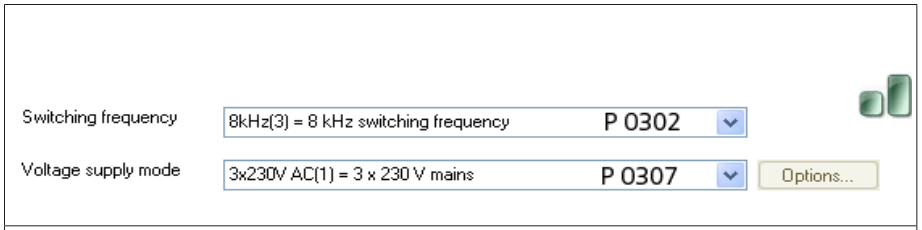



*Bild 1.1 Power stage screen*

Parameter table:

| P. no.: | Parameter name/ Settings | Designation in DM5 | Description |
|---|---|---|---|
| P 0302 | CON_SwitchFreq | Switching frequency | Power stage switching frequency setting. |
| | 2 kHz - 16 kHz (device-specific) | Switching frequency | It is advisable to operate the drive controller with the default setting. Increasing the switching frequency can be useful to improve the control dynamics. Temperature-related derating may occur. Switching frequency noise decreases as the switching frequency rises (audible range < 12 kHz). |
| P 0307 | CON_ VoltageSupply | Voltage supply mode | Adaptation to the voltage conditions |
| | 1x 230 V(0) | Voltage supply mode | Adjustable voltage range |
| | 3x 230 V(1) | | |
| | 3x 400 V(2) | | |
| | 3x 460 V(3) | | |
| | 3x480 V(4) | | |
| | Safety low voltage (5) | | |

## Mains supply

During initial commissioning the mains voltage setting must first be checked and adjusted as necessary via parameter **P 0307 CON_VoltageSupply**. The combination of voltage value and switching frequency corresponds to a stored power stage data set. An unsupported voltage value generates the non-resettable error message **E-02-08**. If an unknown combination of voltage and switching frequency is selected, the resettable error **E-15-05** is generated.

(For an overview of the error codes refer to the "Diagnostics" section.)

Attention: Any changes to parameters must be saved in the device. The setting is only applied on the device after a power off/on cycle.
**If the power stage parameters are changed, the rated currents, overload values and braking chopper thresholds may also change.**

## Switching frequency

As another power stage parameter, the switching frequency can also be set via **P 0302 CON_SwitchFreq**. It is advisable to operate the drive controller with the default setting.

Increasing the switching frequency can be useful to improve the control dynamics. Temperature-related derating may occur. Switching frequency noise decreases as the switching frequency rises (audible range < 12 kHz). For an overview of the currents dependent on the switching frequency refer to the Operation Manual.

# 2. Motor

To start up a system quickly and easily and attain good overall performance, we recommend using LTi standard motors and encoders from the Servomotors catalogue (ID 0814.05B.2-01).

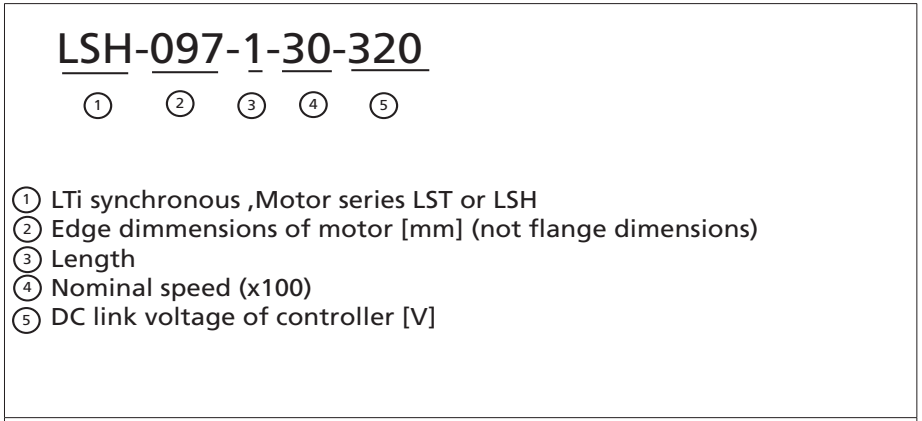

LSH-097-1-30-320
1 2 3 4 5
1 LTi synchronous ,Motor series LST or LSH
2 Edge dimmensions of motor [mm] (not flange dimensions)
3 Length
4 Nominal speed (x100)
5 DC link voltage of controller [V]

*Figure 2.1 Motor key*

Each motors can only be operated if its field model and the control parameters are correctly set. If a third-party motor is used instead of an LTi motor with a matching data set, it is possible to calculate or identify a motor data set.
The difference between the two methods is that when calculating a motor data set the impedances must be taken from the data sheet. The impedances in the case of identification are measured automatically.

## 2.1 PS Motor/Synchronous motor

### 2.1.1 Loading the motor data/Electrical data PS

The LTi website provides a database with the data sets of all LTi standard motors. Using the right motor data set ensures that

- the electrical data of the motor are correctly parameterized,
- the motor protection is correctly set,
- the control circuits of the drive are preset,
- the torque controller is optimally set, so no further adaptations are required for the initial "turnover" of the motor.

#### Motor selection

- Selection of the desired motor data set via Motor selection (possibly LTi DRiVES GmbH website). All necessary parameters (e.g motor protection, control parameters) are read-in.
- With the motor identification the complete motor data set (name, parameter, motion mode) is loaded. Preset parameters are overwritten.
- Save motor data to device.
- The individual items of motor data are displayed in the "Show motor data" window and can be edited manually.

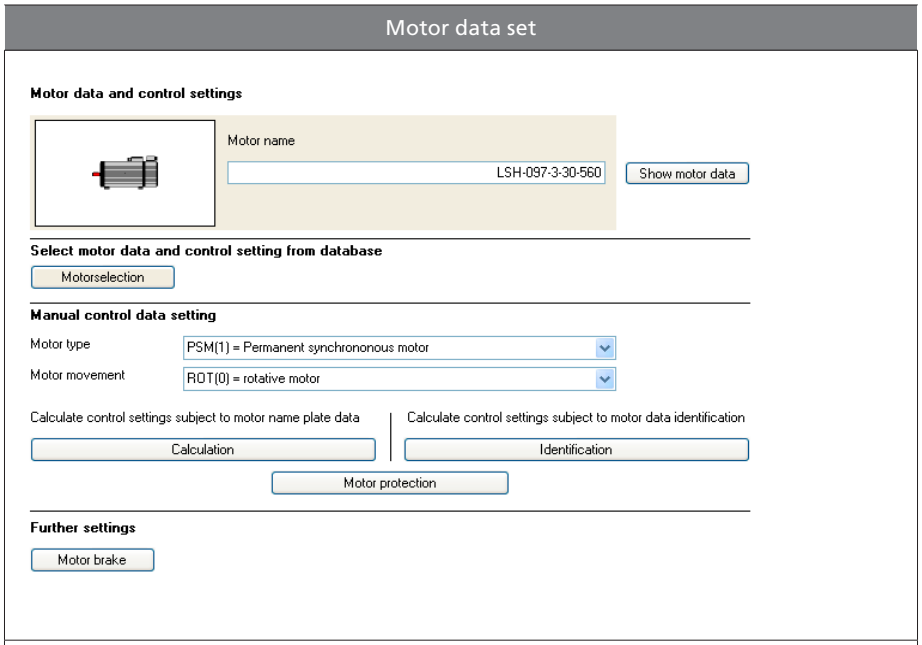



*Figure 2.2 Motor data*

## 2.1.2 Motor calculation

Click the Calculation button to open the dialogue box for calculation of a data set. The motor data relevant to the calculation must be entered manually from the data sheet (see figure 2.3).

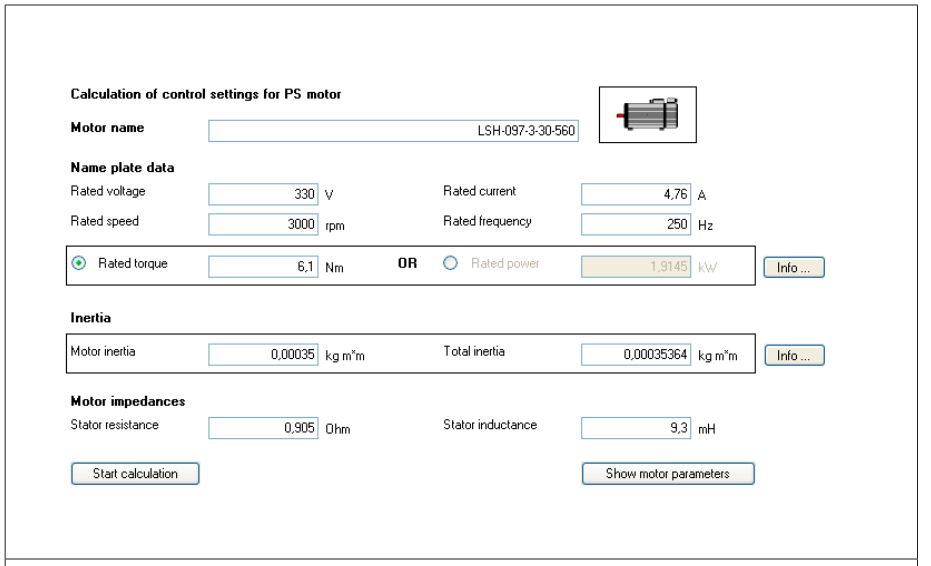



*Figure 2.3 Dialogue box for data set calculation*

Parameters:

| P. no. | Parameter name/ Settings | Designation in DM5 | Function |
|---|---|---|---|
| P 0490 | MOT_IsLinMot -> ROT (0) | Selection if linear or rotatory motor data are valid | Selection for rotary or linear motor |
| P 0450 | MOT_Type -> PSM | Motor type | Motor type (ASM, PSM) |
| P 0451 | MOT_Name [1)] | Name of motor parameter set | Freely selectable motor name |
| P 0455 | MOT_FNom [2)] | Motor rated frequency | Rated frequency of the motor |
| P 0456 | MOT_VNom [2)] | Motor rated voltage (line voltage) | Rated voltage of the motor |
| P 0457 | MOT_CNom [2)] | Motor rated current | Rated current of the motor |
| P 0458 | MOT_SNom | Motor rated speed | Rated speed |
| P 0459 | MOT_PNom [1)] | Motor rated power | Rated power output |
| P 0460 | MOT_TNom | Motor rated torque | Rated torque |
| P 0461 | MOT_J [2)] | Motor inertia | Mass inertia of the motor |

| P. no. | Parameter name/ Settings | Designation in DM5 | Function |
|---|---|---|---|
| P 0463 | MOT_PolePairs | Motor number of pole pairs | Number of pole pairs |
| P 0470 | MOT_Rstat [2)] | Motor stator resistance | Stator resistance |
| P 0471 | MOT_Lsig [2)] | Motor stray/stator inductance | Stator inductance |
| P 1530 | SCD_SetMotor Control | Determination of default motor control settings | Start of calculation |

[1)] The parameters are intended for information only, but should be set for a complete motor data set.

[2)] The parameters are used for calculation of controller settings and have a direct influence on the behaviour of the servocontroller.

If the mass moment of inertia of the motor **P 0461** is not known, a moment of inertia corresponding to a standard motor with the same power output and number of pole pairs is assumed. Click the "Start calculation" button to start the calculation.
The progress of the calculation can be observed on the DM5 **View > Messages** menu by way of the Message window.

### 2.1.3 Motor identification:

- Current controller tuning: Current controller optimization
- Measurement of **P 0476** Rotor resistance, **P 0471** Stray (leakage) inductance for operation below rated current
- Measurement of the saturation characteristic, table values of the stator inductance **P 0472**. Measurements are taken up to 4 times rated current, provided the power stage current permits it at standstill. If it does not, measurements are taken with a correspondingly lower current.
- Calculation of operating point: via **P 0462** Rated flux, **P 0340** Magnetizing current
- Calculation of: current, speed and position control parameters

The following values are calculated:

1. Flux settings (including for torque constant)
2. Control settings for PI current controller: The current controller is dimensioned dependent on the switching frequency setting.
3. PI-speed controller and position controller gain: In this, a moderately rigid mechanism and a 1:1 moment of inertia adjustment from the load to the motor are assumed (if total moment of inertia = 0). If the total mass moment is not equal to 0, the calculation wizard is used to calculate the speed controller with the total mass inertia (**P 1515** = 100 %).
   On each change of parameter **P 1515** the speed and position controller is recalculated.
4. V/F characteristic

Attention: All previous speed and position control parameters are overwritten.

## 2.2 PS Linear motor

To make the calculations based on the characteristic quantities for a linear motor, **P 0490 must be = LIN(1)**. The parameter automatically sets the number of pole pairs of the motor to **P 0463 = 1**. Thus, one pole pitch division from north-to-north corresponds to a virtual revolution **P 0492**.

### Linear PS motor setting

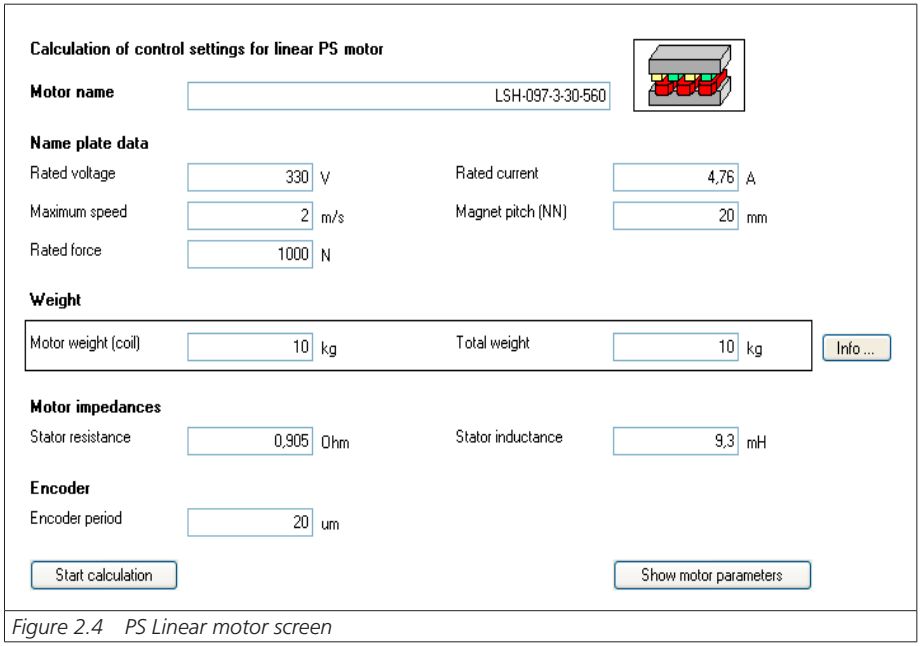



*Figure 2.4 PS Linear motor screen*

Parameter

| P. no. | Parameter name/ Settings | Designation in DM5 | Function |
|---|---|---|---|
| P 0490 | MOT_IsLinMot -> LIN (1) | Selection if linear or rotatory motor data are valid | Selection for rotary or linear motor |
| P 0450 | MOT_Type -> PSM | Motor type | Motor type |
| P 0451 | MOT_Name [1)] | Name of motor parameter set | Motor name |
| P 0457 | MOT_CNom [2)] | Motor rated current | Rated current |
| P 0492 | MOT_MagnetPitch [2)] | Width of one motor pole (NN) | Pole pitch (NN) |
| P 0493 | MOT_SpeedMax [2)] | Maximum (nominal) motor speed | Maximum velocity |
| P 0494 | MOT_ForceNom [2)] | Nominal force of motor | Rated force |
| P 0496 | MOT_MassMotor [2)] | Mass of motor slide | Mass of motor carriage |
| P 0497 | MOT_MassSum [2)] | Mass of total mass, moved by the motor | Total mass to be moved |
| P 0498 | MOT_EncoderPeriod [2)] | Period of line signals | Encoder signal period |
| P 0470 | MOT_Lsig [2)] | Motor stray/stator inductance | Primary section inductance |
| P 0471 | MOT_Rstat [2)] | Motor stator resistance | Stator resistance |

[1)] The parameters are intended for information only, but should be set for a complete motor data set.
[2)] The parameters are used for calculation of controller settings and have a direct influence on the behaviour of the servocontroller.

The following values are calculated:

1. Translation of the linear nominal quantities into virtual rotary nominal quantities.
2. Default values for autocommutation.
3. Encoder lines per virtual revolution.
4. Flux settings (including for torque constant).
5. Control settings for PI current controller: The current controller is dimensioned dependent on the switching frequency setting.

6. PI-speed controller and position controller gain: In this, a moderately rigid mechanism and a 1:1 moment of inertia adjustment from the load to the motor are assumed (if total moment of inertia = 0). If the total mass moment is not equal to 0, the calculation wizard is used to calculate the speed controller with the total mass inertia (**P 1515** = 100 %). On each change of parameter **P 1515** the speed and position controller is recalculated.
7. The default setting of the speed tracking error monitor is 50 %.
8. V/F characteristic.

## 2.3 AS Motor/Asynchronous motor

### 2.3.1 Electrical data/Electrical data AS

For commissioning of third-party motors, the rated data and characteristic variables of the motor must be known and be entered manually in the relevant dialogue box. Click the **Identification** button to calculate the basic setting for the control based on those values. The impedances (stator and stray impedances) are obtained by measurement.

If the identification is successful, the torque control is adequately configured. An adjustment to the machine mechanism and to the motion profile is also required.

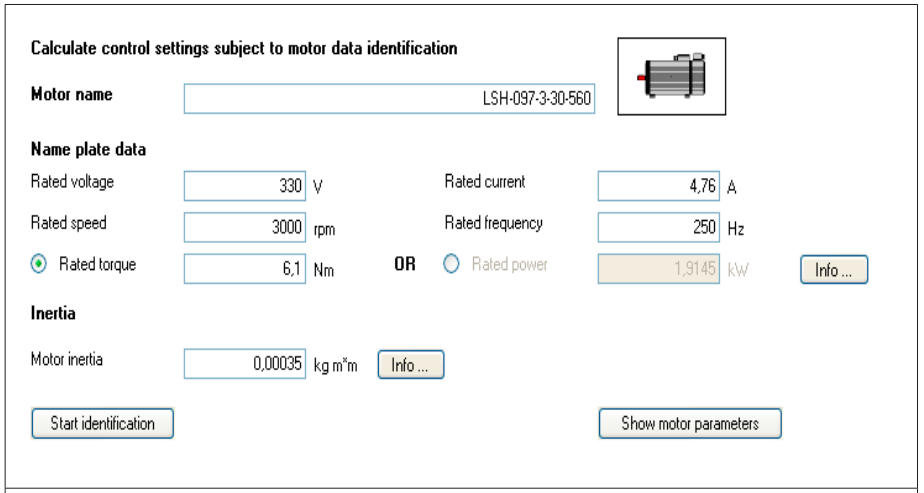



*Figure 2.5 Motor identification*

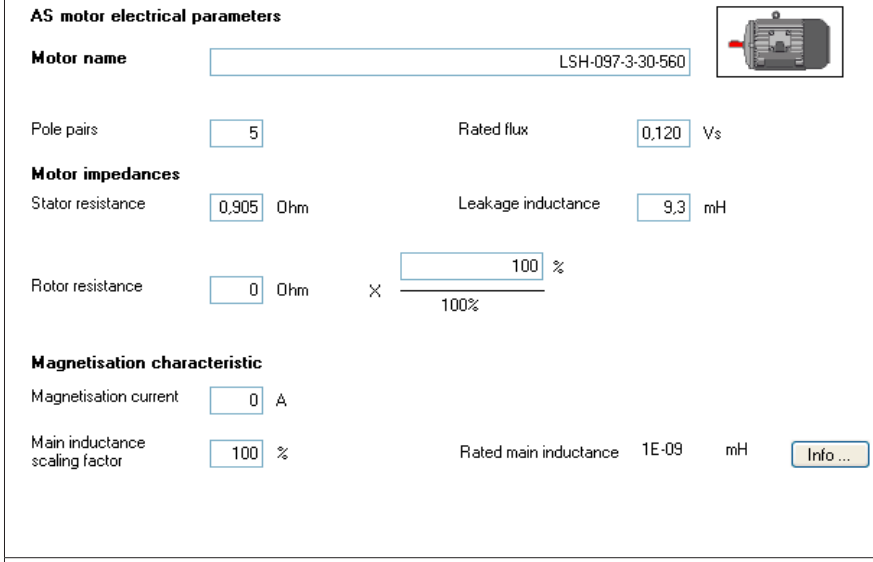



*Figure 2.6 Motor parameters*

For asynchronous motors the following parameters are stored in the dialogue box. In the Parameter Editor motor data can be modified without using dialogue boxes.

| P. no. | Parameter name/ Settings | Designation in DM5 | Function |
|---|---|---|---|
| P 0490 | MOT_IsLinMot -> ROT (0) | Selection if linear or rotatory motor data are valid | Selection for rotary or linear motor |
| P 0450 | MOT_Type -> PSM | Motor type | Motor type |
| P 0451 | MOT_Name [1)] | Name of motor parameter set | Freely selectable motor name |
| P 0452 | MOT_CosPhi | Motor rated cos(phi) | Parameter informative only |
| P 0455 | MOT_FNom [2)] | Motor rated frequency | Rated frequency of the motor |
| P 0456 | MOT_VNom [2)] | Motor rated voltage (line voltage) | Rated voltage of the motor |
| P 0457 | MOT_CNom [2] | Motor rated current | Rated current of the motor |
| P 0458 | MOT_SNom [2] | Motor rated speed | Rated speed |
| P 0459 | MOT_PNom [1)] | Motor rated power | Rated speed |
| P 0460 | MOT_TNom | Motor rated torque | Rated torque |
| P 0461 | MOT_J [2] | Motor inertia | Mass inertia of the motor |
| P 0470 | MOT_Rstat [2)] | Motor stator resistance | Stator resistance |
| P 0471 | MOT_Lsig [2] | Motor stray/stator inductance | Stator inductance |
| P 0478 | MOT_LmagNom | Motor main inductance | Motor main inductance, corresponding to rated magnetizing current P 0340 |
| P 1530 | SCD_SetMotor Control | Determination of default motor control settings | Start of calculation |

[1)] The parameters are intended for information only, but should be set for a complete motor data set.
[2)] The parameters are used for calculation of controller settings, but have no direct influence on the behaviour of the servocontroller. All other parameters have a direct effect.

If the mass moment of inertia of the motor **P 0461 MOT_J** is not known, a moment of inertia for a standard motor is calculated from the power output and number of pole pairs. The progress of the identification can be observed on the DM5 View > Messages menu by way of the Message window.

## Identification sequence:

- Current controller tuning
- Measurement of: **P 0470** Stator resistance, **P 0476** Rotor resistance, **P 0471** Stray (leakage) inductance
- Max. effective current Idmax **P 0474**
- Calculation of operating point: **P 0462** Rated flux, **P 0340** of magnetizing current
- Calculation of: current, speed and position control

Attention: All existing motor parameters are overwritten.

### Calculation of motor data from rating plate data

Input of rated data as above. Parameter **P 0452 MOT_CosPhi** must additionally be entered. By setting **P 1530 SCD_SetMotorControl = 2** the motor parameters of the asynchronous machine are calculated. Parameters calculated are **P 0470 MOT_Rstat, P 0471 MOT_Lsig**, the main inductance in the basic setting range **P 0473 MOT_LmagTab**, **P 0474 MOT_LmagIdMa**x and the flux **P 0462 MOT_FluxNom**, **P 0340 CON_FM_Imag**.

### Identification sequence:

- Calculation of: **P 0470** Stator resistance, **P 0476** Rotor resistance, **P 0471** Stray (leakage) inductance
- Calculation of main inductance in the basic setting range **P 0473**, **P 0474**
- Calculation of operating point: **P 0462** Rated flux, **P 0340** Quadratic mean of magnetizing current
- Calculation of: current, speed and position control

## 2.3.2 Saturation characteristic for main inductance

The main inductance is frequently determined inaccurately, in particular for higher-powered motors. An improvement of this value can be achieved at high speed, with no load on the machine if possible, by way of a measurement process.

Procedure:

– Run motor at 50 - 90 % of rated speed (e.g. via Manual mode)

– Tuning is started when **P 1531 Tune Lmag characteristics = 4**

Sequence:

– The main inductance is determined with varying magnetization.

– The results are written to parameters P **0473 MOT_LmagTab, P 0474 MOT_LmagIdMax**.

The operating point is recalculated.

## 2.3.3 Motor protection

The I²xt monitor protects the motor against overheating throughout the speed range. This is especially important for internally cooled motors. When IEC asynchronous standard motors (ASM) are operated for a prolonged period of time at low speed, the cooling provided by the fan and the housing is insufficient. Consequently, for an internally cooled ASM a reduction of the maximum permissible continuous current dependent on the rotation frequency is required. When set correctly, the I2xt monitor replaces a motor circuit-breaker. The characteristic can be adapted to the operating conditions by way of the interpolation points.

### Temperature monitor setting

The device can evaluate different temperature sensors. With P 0732 the sensor fitted in the motor and the wiring variant are set (sensor cable routed in resolver or separate). In an evaluation via KTY, the shut-off threshold of the motor temperature can additionally be set.

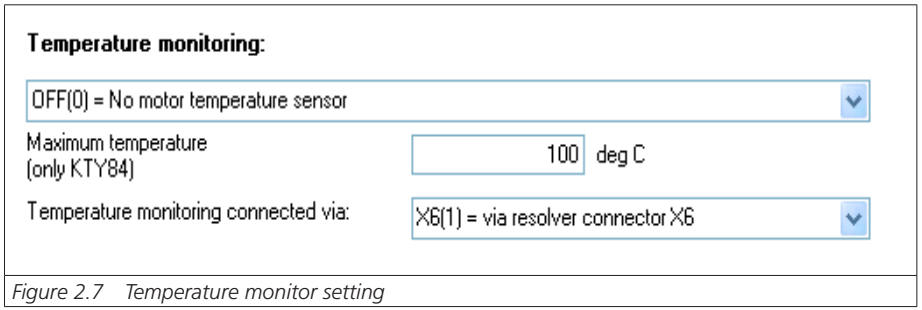



*Figure 2.7 Temperature monitor setting*

### Parameter for temperature monitor setting:

The values refer to the rated motor current **P 0457 MOT_CNom**.

- **P 0732(0)** selects the matching motor temperature sensor
- **P 0732(1)** selects the matching wiring variant
- **P 0731(0)** If thermal protection is implemented by way of a KTY, the trigger temperature is set via this parameter.

| P. no. | Parameter name/ Settings | Designation in DM5 | Function |
|---|---|---|---|
| P 0731 | MON_MotorTem-Max_ | Max. motor temperatur, switch off value | Shut-off threshold for KTY |
| 0 | 0-1000 | - | Factory setting: 100 % |
| P 0732 | MON_MotorPTC | Select motor temperature sensor | Selection of sensor type |
| (0) | OFF(0) | No sensor | No evaluation |
| | KTY(1) | KTY84-130 sensor | KTY84-130 |
| | PTC(2) | PTC with short circuit proof | PTC to DIN 44081 with short-circuit monitoring |
| | TSS(3) | Switch Klixon | Klixon switch |
| | PTC1(4) | PTC1 without short circuit proof | PTC to DIN 44081 without short-circuit monitoring |
| | Not used(5) | | |
| | NTC(6) | NTC sensor(6) | Only on enquiry (adapter) |
| (1) | contact | Sensor connection | Connection variant |
| | X5(0) | Motor temperature connector X5 | Connection of the sensor to terminal X5 |
| | X6(1) | Via Resolver connector X6 | Sensor connection is routed in resolver cable |
| P 0733 | MON_MotorI2t | Motor I2t protection parameters | Setting of I2t characteristic |
| (0) | $I_{nom}$ [%](0) | Rated current FNom | Rated current of the motor |
| (1) | $I_0$ [%](1) | Rated current (0 Hz) | First current interpolation point of motor protection characteristic: Maximum permissible standstill current |

| P. no. | Parameter name/ Settings | Designation in DM5 | Function |
|---|---|---|---|
| (2) | $I_1$ [%](2) | Rated current (f1) | Second current interpolation point of motor protection characteristic referred to maximum characteristic current |
| (3) | $f_1$ [Hz](3) | Interpolation point-only ASM | First frequency interpolation point of motor protection characteristic |
| (4) | $f_N$ / F(*f*) [Hz] (4) | Nominal frequency | Rated frequency |
| (5) | $I_{max}$ [%](5) | Motor maximum currrent | Max. overload current referred to rated motor current |
| (6) | $t_{max}$ [sec](6) | Motor maximum currrent | Overload time $t_{max}$ at $I_{max}$ |

## Characteristic setting for an asynchronous motor (ASM)

When internally cooled ASMs are operated for a prolonged period of time at low speed, the cooling provided by the fan and the housing is insufficient. Consequently, for an internally cooled ASM a reduction of the maximum permissible continuous current dependent on the rotation frequency is required.

## Motor protection characteristic setting

To protect the motor, as a rule of thumb the motor protection characteristic and operation of the IEC asynchronous motor should conform to the following limit values:

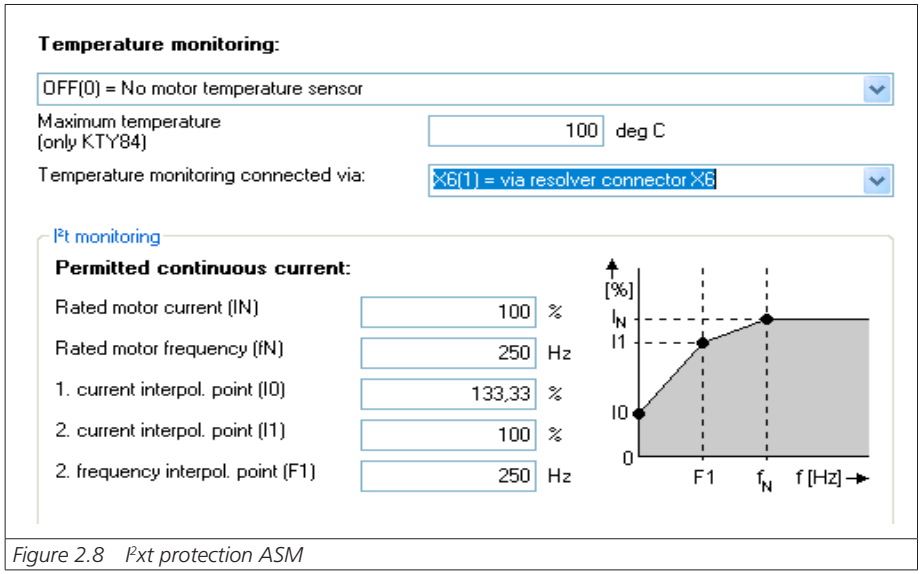



*Figure 2.8 I²xt protection ASM*

It is necessary to adapt the I2t characteristic because the factory settings mostly do not exactly map the current motor. The difference between factory setting and the characteristic configured above is shown in the following illustration.

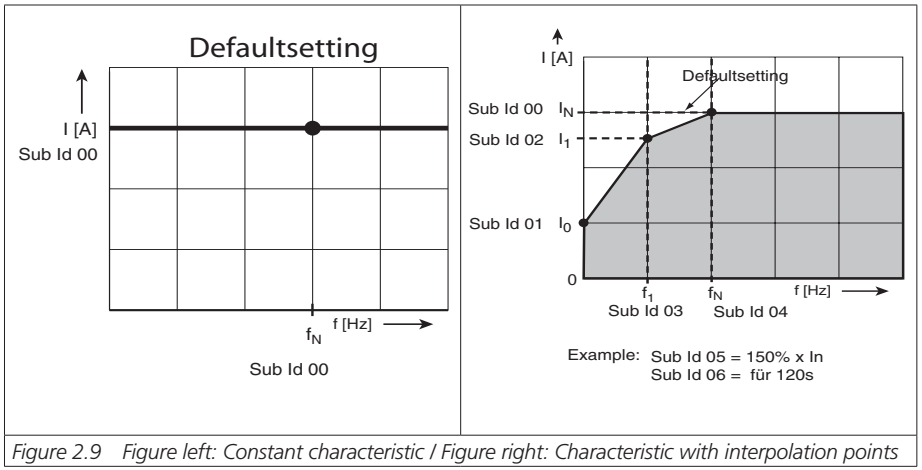



*Figure 2.9 Figure left: Constant characteristic / Figure right: Characteristic with interpolation points*

| Frequency (Hz) | Rated motor current (%) |
|---|---|
| 0 | 30 ($I_0$) |
| 25 ($f_1$) | 80 ($I_1$) |
| 50 ($f_N$) | 100 ($I_N$) |

The shut-off point to VDE 0530 for IEC asynchronous standard motors is

**150 % x IN for 120 s.**

For servomotors, it is advisable to set a constant characteristic. The switch-off point defines the permissible current-time area up to switching off.

Note: For servomotors, refer to the motor manufacturers' specifications.

If the integrator exceeds its limit value, the error **E-09-01** is triggered. The current value of the integrator is indicated in parameter **P 0701 (0)**.

Note: The limits are specified in the servocontroller as percentages of the rated quantities (e.g. current, torque, speed,...), so that following calculation logical default settings are available. The default settings refer to 100% of the rated values and the parameters must thus be adapted to application and motor.

## Characteristic setting for a permanently excited synchronous motor (PSM)

A synchronous motor by design has lower loss than the ASMs (because permanent magnets replace the magnetizing current). It is normally not internally cooled, but discharges its heat loss by internal convection. For that reason it has a different characteristic, which typically looks like this:

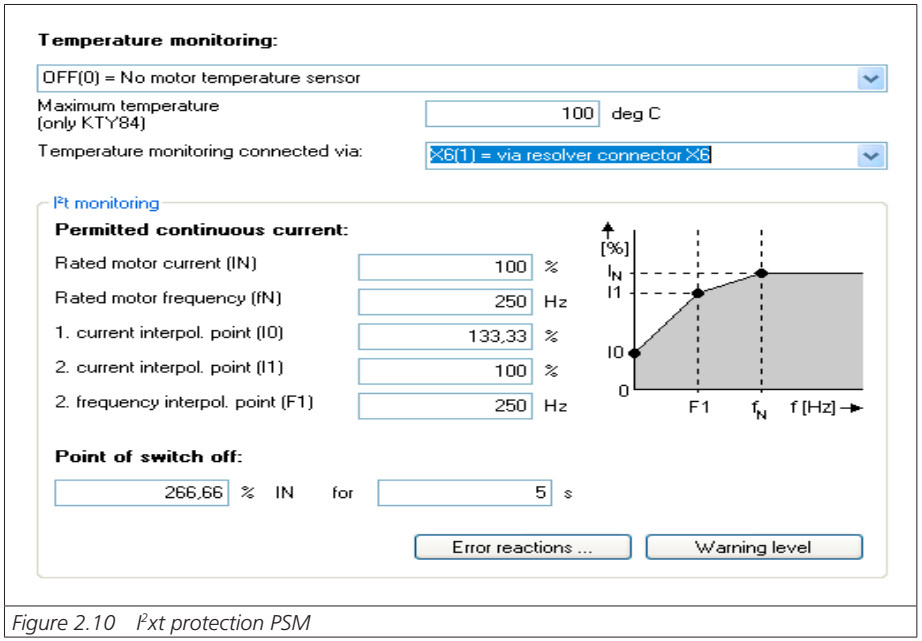



*Figure 2.10 I²xt protection PSM*

It is necessary to adapt the I²xt characteristic because the factory settings mostly do not exactly map the current motor. The difference between factory setting and the characteristic configured above is shown in the following illustration.

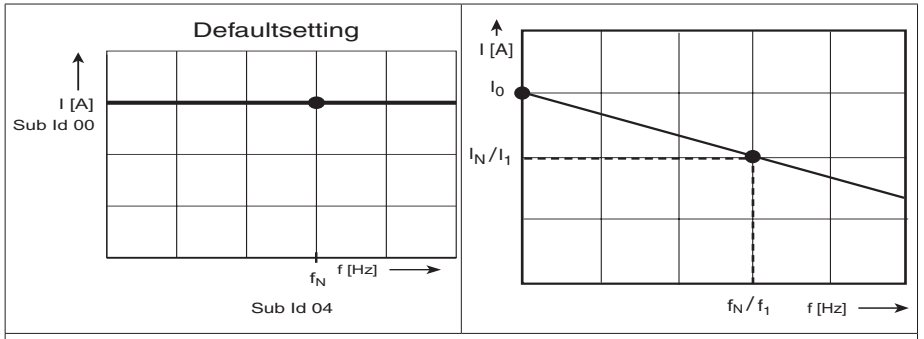



*Figure 2.11 Characteristic of PSM*

If the preset integrator exceeds its limit value, the error E-09-01 is triggered (see "Diagnostics" section). The current value of the integrator is indicated in parameter P 0701 (1).

# 3. Encoder

A range of encoder variants are available to measure the position and speed. The encoder interfaces can be flexibly selected for a specific application.

## Selection of encoder channels (CH1, CH2, CH3)

Up to three encoder channels can be evaluated at a time. The evaluation is made via connectors X6 and X7. They are part of the controller's standard on-board configuration. A third channel X8 can be ordered as an optional encoder.

The dialogue box (figure 3.1) is used to set the encoders for torque, speed and the position.

The "Encoder offset/Detect" option accesses a wizard to define the current encoder offset. For the definition the motor is run in "Current control" mode. For a correct definition it is necessary for the motor to be able to align itself freely. External load torques will corrupt the result.

The motor is supplied with a voltage so that the motor shaft can align itself. Attention: The motor shaft must be able to move. A connected brake is automatically vented, if connected to the brake output. The process takes about 10 seconds. Then the current value of the offset is entered in the display field and the original parameter setting is restored.

## Interfaces between encoder and control

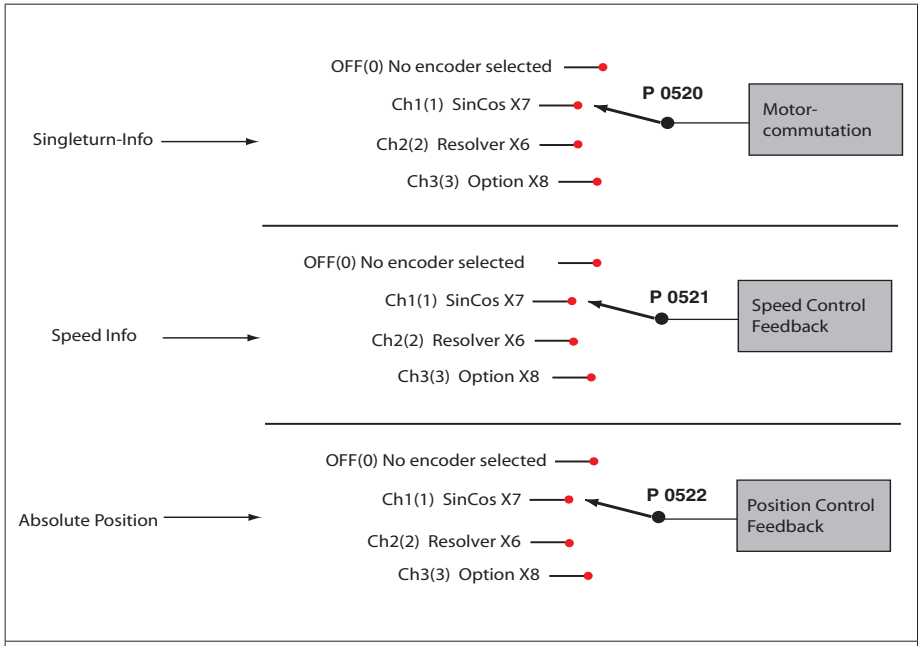



*Figure 3.1 Interface configuration between encoder channels and control*

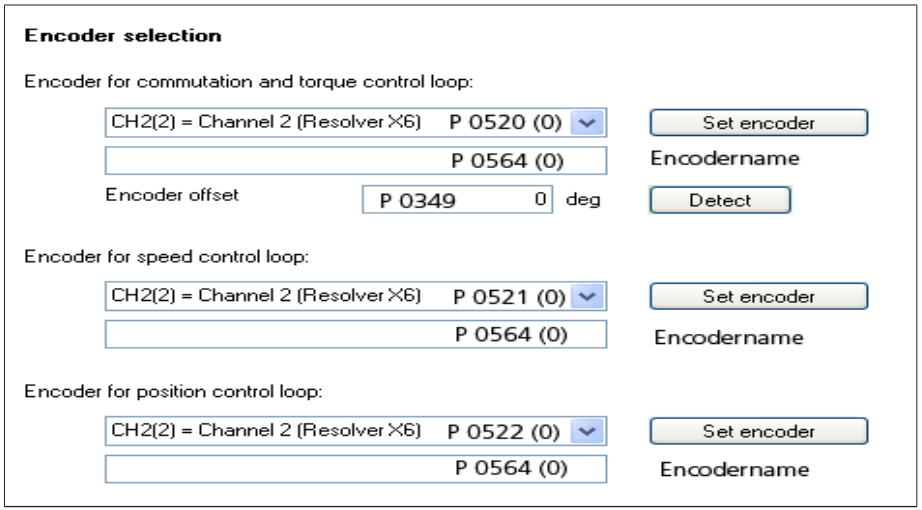



*Figure 3.2 Dialogue box for setting the encoder channel*

## Assignment of encoder information to control

| P. no. | Parameter name/ Settings | Description in DM5 | Function |
|---|---|---|---|
| P 0520 | ENC_MCon | Encoder: Channel Select for Motor Commutation | Selection of encoder channel for commutation angle (feedback signal for field oriented control) |
| P 0521 | ENC_SCon | Encoder: Channel Select for Speed Control | Selection of encoder channel for speed configuration (feedback signal for speed control) |
| P 0522 | ENC_PCon | Encoder: Channel Select for Position Control | Selection of encoder channel for position information (feedback signal for position control) |

Note: When an encoder channel is selected and an encoder physically connected to the controller, the wire break detector is automatically activated.

# 3.1 SinCos X7 (channel 1)

Encoder channel 1 is used for evaluation of high-resolution encoders.

The signal resolution is 12-bit over one track signal period.

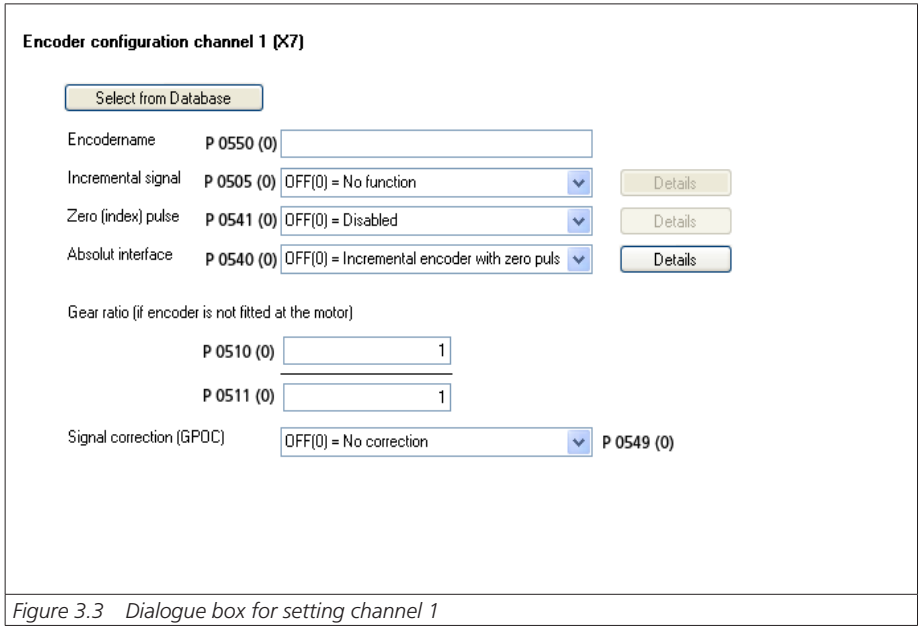

Encoder configuration channel 1 (X7)
Select from Database
Encodername P 0550 (0)
Incremental signal P 0505 (0) OFF(0) = No function
Details
Zero (index) pulse P 0541 (0) OFF(0) = Disabled
Details
Absolut interface P 0540 (0) OFF(0) = Incremental encoder with zero puls
Details
Gear ratio (if encoder is not fitted at the motor)
P 0510 (0) 1
P 0511 (0) 1
Signal correction (GPOC) OFF(0) = No correction P 0549 (0)

*Figure 3.3 Dialogue box for setting channel 1*

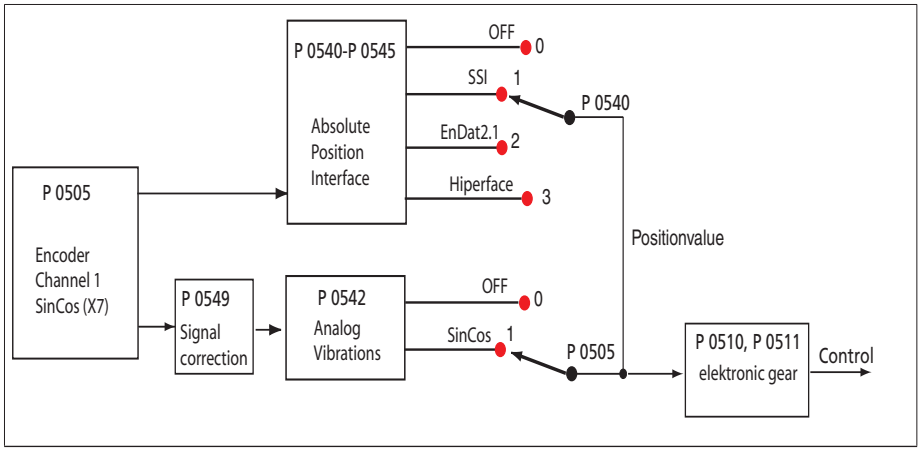



*Figure 3.4 Encoder configuration based on example of channel 1*

Overview of parameters for channel 1

| P. no. | Parameter name/ Settings | Designation in DM5 | Function |
|---|---|---|---|
| P 0505 | ENC_CH1_Sel | Encoder channel 1: Select | Configuration of the incremental interface |
| (0) | OFF | " | No evaluation |
| (1) | SinCos | " | High-resolution SinCos encoder with fine interpolation |
| (2) | SSI | " | Purely digital encoder via serial communication |
| P 0542 | ENC_CH1_Lines | Encoder channel 1: Number of Lines SinCos-Encoder | Setting of the incremental number of lines. For encoders with EnDat2.1 and Hiperface protocols the lines per revolution are read out of the encoder and automatically parameterized1). |
| | 1 - 65535 | | |
| | | | |
| P 0540 | ENC_CH1_Abs | Encoder channel 1: Absolute Position Interface | Definition of protocol type: When starting the device and after changing the encoder parameters, the absolute position of an incremental measuring system is read out via a digital interface. |
| P 0541 | ENC_CH1_Np | Encoder Channel 1: Index Pulse Test-Mode | Zero pulse evaluation |
| P 0542 | ENC_CH1_Lines | Encoder Channel 1: Number of Lines SinCos-Encoder | Setting of the incremental number of lines. For encoders with EnDat2.1 and Hiperface protocols the lines per revolution are read out of the encoder and automatically parameterized**1).** |
| P 0543 | ENC_CH1_MultiT | Encoder Channel 1: Number of MultiTurn Bits | Multiturn: Bit width setting |
| P 0544 | ENC_CH1_SingleT | Encoder Channel 1: Number of SingleTurn Bits | Singleturn: Bit width setting |
| P 0545 | ENC_CH1_Code | Encoder Channel 1: Code Select | Selection of coding: Gray/binary |

**1)** For EnDat2.1 and Hiperface, the single/multiturn, coding and lines per revolution information is automatically read from the encoder.

### 3.1.1 Zero pulse evaluation via encoder channel 1

The zero pulse evaluation via encoder channel CH1 is only set "active" for SinCos encoders with no absolute value interface.

Setting:
**P 0505 ENC_CH1_Sel** (setting "SinCos encoder")
**P 0540 ENC_CH1_Abs** (setting "OFF": Incremental encoder with zero pulse):

- Sin/Cos encoders only ever output a zero pulse when no absolute value interface is present.
- TTL encoders always have a zero pulse.
- Resolvers output no zero pulse.

Zero pulse evaluation only works by selecting the intended homing types (see "Homing" in "Motion profile" section).

#### Test mode for zero pulse detection

Test mode is activated by parameter **P 0571 ENC_CH3_Np =1**. Encoder initialization is triggered manually by **P 0149 MPRO_DRVCOM_Init =1**. Homing runs can also be carried out during test mode.

When homing is completed, or if an error has occurred, detection is aborted even though parameter **P 0541 = 1**. To reactivate test mode, parameter **P 0541** must be reset from 0 to 1 and re-initialized.

To view the zero pulse with the scope function, the variable **CH1-np-2** (index pulse length 1 ms) can be recorded on the digital scope.

ATTENTIONG: The pulse width of the scope signal does not match the pulse width of the actual zero pulse. The representation on the scope appears wider (1 ms when using variable **CH1-np-2**), enabling better detection of the zero pulse. The decisive factor here is the rising edge of the scope signal.

### 3.1.2 Encoder correction (GPOC)

For **each channel** the GPOC (**G**ain **P**hase **O**ffset **C**orrection) method can be activated for the analog track signals. This enables the mean systematic gain, phase and offset errors to be detected and corrected. GPOC weights the amplitude of the complex pointer described by the track signals by special correlation methods. The dominant errors can thereby be determined very precisely, with no interference from other encoder errors, and then corrected. There are two GPOC variants to use. Track signal correction can be used with stored values (CORR) or with online tracked values (ADAPT) . Where multiple encoders are in use, it is advisable to apply the method for the encoder used to determine the velocity signal.

Parameters for GPOC encoder correction based on the example of channel 1:

| P. no. | Parameter name/ Settings | Designation in DM5 | Function |
|---|---|---|---|
| P 0549<br>P 0561 | ENC_CH1/2_Corr | Encoder Channel 1/2: Signal Correction | Selection of correction method |
| 0 | OFF | No reaction | No method |
| 1 | CORR | Correction with saved values | Activate correction with stored values |
| 2 | ADAPT | Auto correction | Autocorrection |
| 3 | RESET | Reset correction values | Reset values |
| P 0550,<br>P 0562 | ENC_CH1/<br>2_CorrVal | Encoder Channel 1/2:<br>Signal Correction Values | Signal correction |
| 0 | Offset A | Offset, track A | Defined offset of track signal A |
| 1 | Offset B | Offset, track B | Defined offset of track signal B |
| 2 | Gain A | Gain track A-SinCos | Determined gain correction factor for track signal A |
| 3 | Gain B | Gain track B-sin | Defined gain correction factor for track signal B |
| 4 | Phase | phase | Calculated phase correction between track signals A and B |

Encoder correction::

- Open the open-loop control window and set speed-controlled mode.
- Set the optimization speed
  Resolver: approx. 1000 to 3000 rpm
  Optical encoder: approx. 1 to 5 rpm
- Adjust scope: Plot actual speed value
- Switch to “ADAPT” during operation and wait about 1-3 minutes for the compensation algorithms to reach their steady state. The speed ripple should decrease after about 1 minute (observed with scope).
- Apply setting and save secure against mains power failure.
- Procedure 1: Access the stored values with “CORR” or
- Procedure 2: Use current correction values with “ADAPT”
- With the “Reset” setting the values are restored to their factory defaults.

Note: The setting made with “ADAPT” applies only to the motor with which the function was executed. If the motor is replaced by another of the same type, this method must be applied again.

For channel 3 encoder correction as from software version V 2.0 is configured.

## 3.2 Resolver X6 (channel 2)

Channel 2 evaluates a resolver by default.

Functions of encoder channel 2: A 12-bit fine interpolation over one track signal period takes place. The pole pairs are set via **P 0560 ENC_CH2_Lines**.

An additional function is shut-off of the excitation for evaluation of a Hall sensor (for more information consult the LTi Helpline).

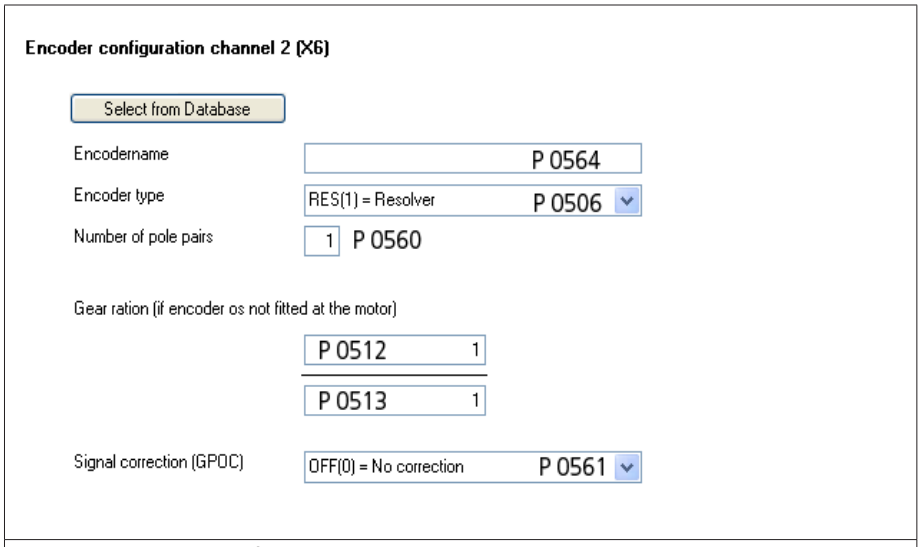



*Figure 3.5 Dialogue box for setting channel 2*

| P. no. | Parameter name/ Settings | Description in DM5 | Function |
|---|---|---|---|
| P 0564 | ENC_CH2_Info | Encoder information ch2 | Encoder name |
| P 0506 | ENC_CH2_Sel | Encoder Channel 2: Select | Interface configuration |
| | OFF (0) | | No evaluation |
| | RES (1) | | Resolver evaluation |
| P 0512 | ENC_CH2_Num | ENC CH2: Gear Numerator | Numerator of transmission ratio |
| P 0513 | ENC_CH2_Denom | ENC_CH2: Gear Denominator | Denominator of transmission ratio |
| P 0560 | ENC_CH2_Lines | Encoder Channel 2: Number of Pole Pairs | Parameterization of number of pole pairs of resolver |
| P 0561 | ECC_CH2_Corr | ENC_CH2: Signal correction type | The GPOC encoder correction function (see section 3.2.2) is also available to channel 2. |

## 3.3 Optional encoder module X8 (channel 3)

With the channel 3 encoder module option the same encoder types can be evaluated as in channel 1 (SinCos/TTL/SSI)

The ServoOne EnDat2.1/SinCos module specification details encoder channel 3.

**Note:** When using two identical encoders, the speed encoder should be connected to channel 1 and the position encoder to channel 3 in order to obtain optimum controller performance.

## 3.4 Encoder gearing

For channels 1 and 3 one gear ratio each can be set for the encoder:

- Adaptation of a load-side encoder to the motor shaft
- Inversion of the encoder information

For encoder channel 2 it is assumed that the resolver is always mounted on the motor shaft. The adjustment range is therefore limited to 1 or -1, i.e the encoder signal can only be inverted.

Parameters of encoder gearing:

| P. no. | Parameter name/ Settings | Designation in DM5 | Function |
|---|---|---|---|
| P 0510 | ENC_CH1_Num | Encoder Channel 1: Gear Nominator | Denominator in channel 1 |
| P 0511 | ENC_CH1_Denom | Encoder Channel 1: Gear Denominator | Nominator in channel 1 |
| P 0512 | ENC_CH2_Num | Encoder Channel 2: Gear Nominator | Denominator in channel 2 |
| P 0513 | ENC_CH2_Denom | Encoder Channel 2: Gear Denominator | Nominator in channel 2 |
| P 0514 | ENC_CH3_Num | Encoder Channel 3: Gear Nominator | Denominator in channel 3 |
| P 0515 | ENC_CH3_Denom | Encoder Channel 3: Gear Denominator | Nominator in channel 3 |

## 3.5 Increment-coded reference marks

In the case of relative encoders with increment-coded reference marks, multiple reference marks are distributed evenly across the entire travel distance. The absolute position information, relative to a specific zero point of the measurement system, is determined by counting the individual measuring increments between two reference marks.

The absolute position of the scale defined by the reference mark is assigned to precisely one measuring increment. So before an absolute reference can be created or the last selected reference point found, the reference marks must be passed over.

To determine reference positions over the shortest possible distance, encoders with increment-coded reference marks are supported (e.g. HEIDENHAIN ROD 280C). The reference mark track contains multiple reference marks with defined increment differences. The tracking electronics determines the absolute reference when two adjacent reference marks are passed over – **that is to say, after just a few degrees of rotation**.

### Rotary measurement system:

**Rotary encoder (figure 3.6):**

Basic increment, **reference measure A**: (small increment, e.g. **1000**)
corresponding to parameter **P 0610 ENC_CH1_Nominal increment** A

Basic increment, **reference measure B**: (large increment, e.g. **1001**)
corresponding to parameter **P 0611 ENC_CH1_Nominal Increment B**
The number of lines is entered in parameter **P 0542 ENC_CH1_Lines**.

A sector increment difference of +1 and +2 is supported.

One mechanical revolution is precisely one whole multiple of the basic increment A.

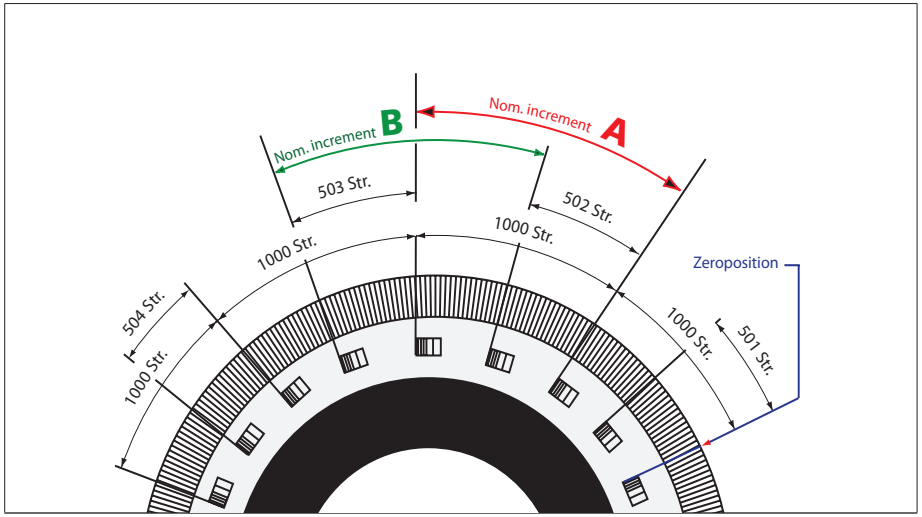



*Figure 3.6 Schematic view of circular graduations with increment-coded reference marks*

## Example of a rotary measurement system

| Number of lines P 0542 | Number of reference marks | Basic increment G Nominal Increment A P 0610 | Basic increment G Nominal Increment B P 0611 |
|---|---|---|---|
| 18 x 1000 lines | 18 basic marks + 18 coded marks = ∑36 | Reference measure A = 1000 lines, corresponding to 20° | Reference measure B 1001 lines |

## Linear measurement system:

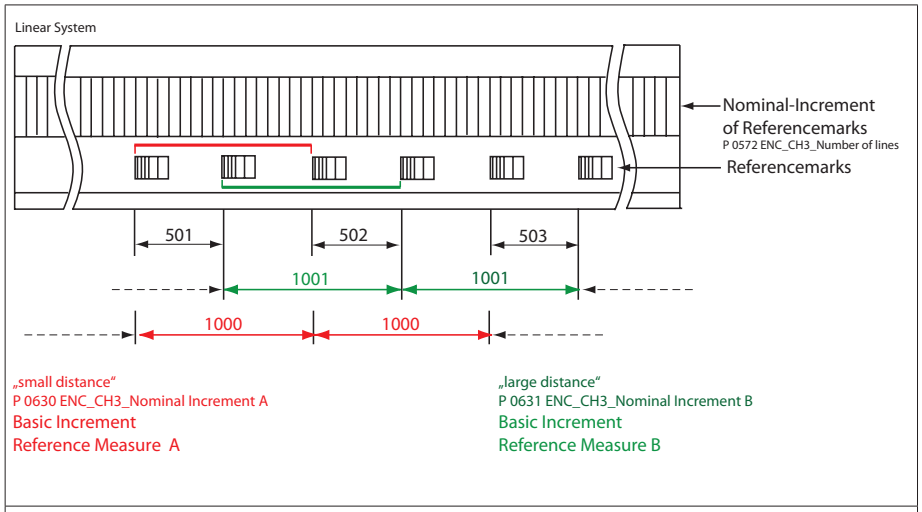



*Figure 3.7 Schematic view of a linear scale with increment-coded reference marks*

## 3.6 Pin assignment for X6 and X7/X8

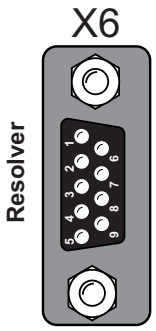
| | X6 / PIN | Assignment | Description |
|---|---|---|---|
|  | 1 | Sin + | (S2) Analog differential input track A |
| | 2 | Refsin | (S4) Analog differential input track A |
| | 3 | Cos + | (S1) Analog differential input track B |
| | 4 | - | Internally connected to pin 7 |
| | 5 | ϑ + | (PTC, KTY, Klixon) |
| | 6 | Ref + | (R1) Analog excitation at (16 KHz, 8-11 V AC) |
| | 7 | Ref - | (R2) Analog excitation |
| | 8 | Refcos | (S3) Analog differential input track B |
| | 9 | ϑ - | (PTC, KTY, Klixon) |

*Figure 3.8 Pin assignment, resolver on X6*

| | X7 / PIN | SINCOS | Absolute encoder SSI/ EnDat 2.1 | Absolute encoder HIPERFACE© |
|---|---|---|---|---|
| | 1 | A- | A- | REFCOS |
| | 2 | A+ | A+ | + COS |
| | 3 | + 5 V / max 150 mA | + 5 V / max 150 mA | Jumper between pins 7 and 12 produces a voltage of 12V / 100 mA on X7/3 |
| | 4 | - | Data + | Data + |
| | 5 | - | Data - | Data - |
| | 6 | B- | B - | REFSIN |
| | 7 | - | - | Us-Switch |
| | 8 | GND | GND | GND |
| | 9 | R - | - | - |
| | 10 | R + | - | - |
| | 11 | B + | B + | + SIN |
| | 12 | Sense + | Sense + | Us-Switch |
| | 13 | Sense - | Sense - | - |
| | 14 | - | CLK + | - |
| | 15 | - | CLK - | - |

*Figure 3.9 Pin assignment, connector X7*

Attention: A jumper between X7/7 and 12 delivers a voltage rise up to 11.8 V on X7/3 (only for use of a Hiperface encoder).

Attention: Encoders with a voltage supply of 5 V +5% must have a separate sensor cable connection. The sensor cables are required to measure a supply voltage drop on the encoder cable. Only use of the sensor cables ensures that the encoder is supplied with the correct voltage. The sensor cables must always be connected!
If a SinCos encoder delivers no sense signals, connect pins 12 and 13 (+ / -Sense) to pins 3 and 8 (+ 5 V/GND) on the encoder cable end.

# 4. Closed-loop control

## 4.1 Control basic setting

A servocontroller works on the principle of field-oriented regulation. In the motor the current is injected where the magnetic flux is at the maximum. This produces a maximum torque on the motor shaft or on the carriage of a linear motor.

Specified properties:

- Constant speed (synchronism)
- Positioning accuracy (absolute and repeatable)
- High dynamics
- Constant torque
- Disturbance adjustment

When using a LTi DRiVES standard motor data set, the control parameters are preset for the specific motor model. If using third-party motors, a manual setting must be made for den drive by way of the motor identification or by calculation in order to get the appropriate control parameters for the motor model (see "Motor" section).

The individual controllers for position, speed and current are connected in series (see figure 4.1). The matching control loops are selected by the control mode.

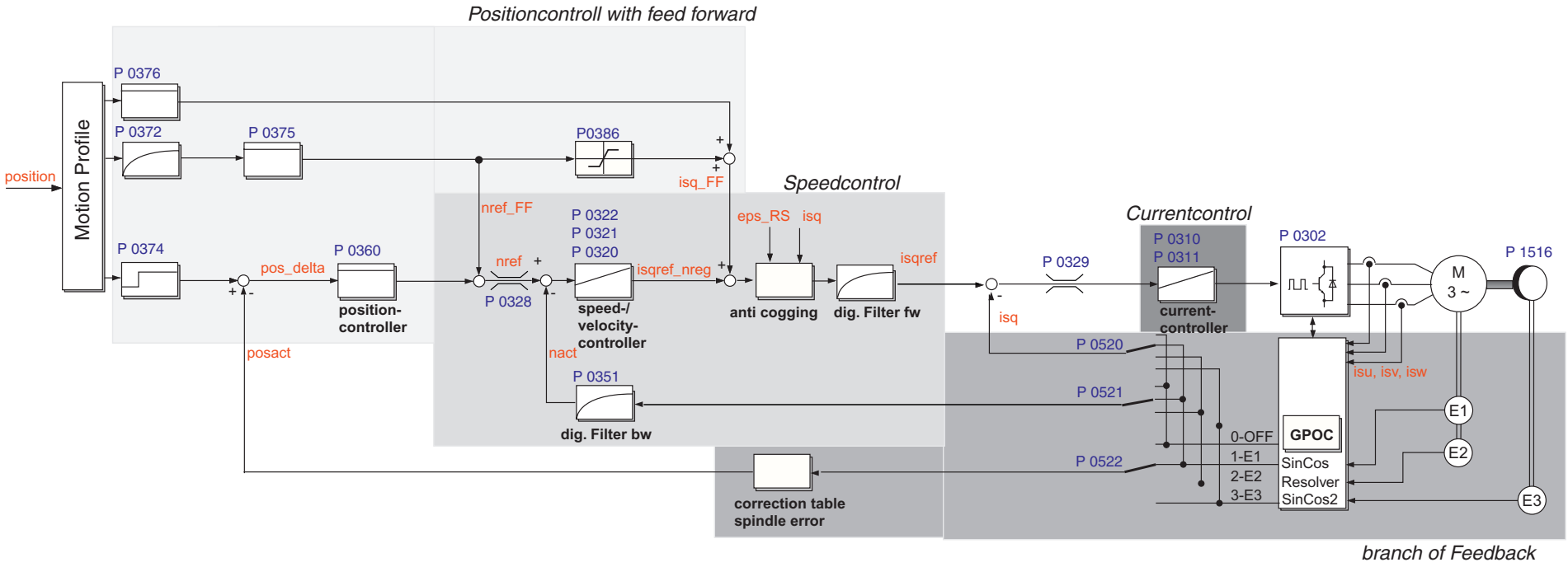



*Figure 4.1 Control structure*

Note: Synchronous and asynchronous machines and also synchronous linear motors (ironless/iron-core) can be controlled.

Owing to the cascade structure of the control loops, it is necessary to perform the optimization "from the inside outwards".

Sequence for optimization of controllers:

1. Current control loop: For LTI motors with motor encoder optimization of the current controller is not needed because the corresponding parameter values are transferred when the motor data set is loaded. For linear motors and third-party motors the motor must be identified (section 3, "Motor").
2. Speed controller: The settings of the speed controller with the associated filters are dependent, firstly, on the motor parameters (mass moment of inertia and torque/force constant) and, secondly, on mechanical factors (load inertia/mass, friction, rigidity of the connection,...). Consequently, a manual or automatic optimization is often required.
3. Position control loop: The position control loop is dependent on the dynamics of the underlying speed controller, on the reference type and on the jerk, acceleration and interpolation methods.

The basic control settings are made on the Control screen.

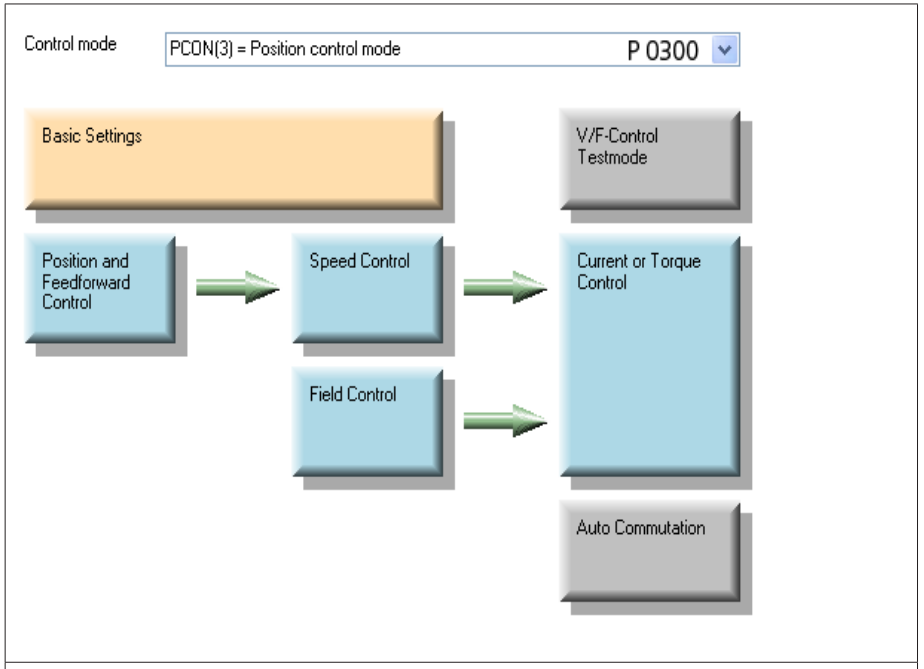



*Figure 4.2 Control screen for selection of the control parameters*

Parameter **P 0300 CON_CFG_Con** specifies the control mode with which the drive is to be controlled. **This parameter takes effect online.** Uncontrolled online switching can cause an extreme jerk, a very high speed or an overcurrent, which may cause damage to the system.

Selection of control mode:

- Current control TCON(1)
- Speed control SCON(2)
- Position control PCON(3)

### 4.1.1 Basic settings

The "Basic settings" button opens the dialogue box for control-related basic settings. The basic settings include:

- Mass moment of inertia of system
- Rigidity, speed controller scaling
- Current/speed/position control gain factors
- Speed filter

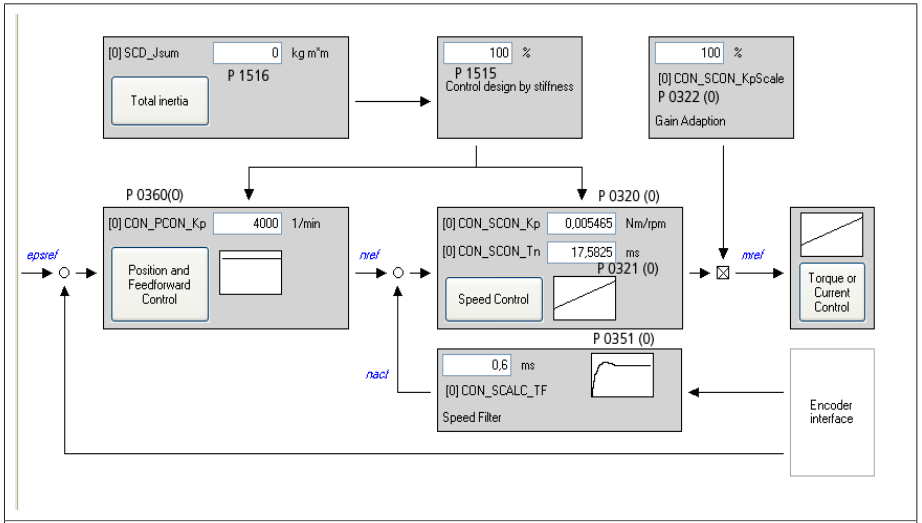



*Figure 4.3 Basic setting dialogue box*

#### Adaptation to the system mechanism

In the standard motor data set the speed controller is preset for a moderately stiff mechanism. For load adaptation the coupled, reduced mass moment of inertia of the system is equal to the motor's moment of inertia (load to motor ratio 1:1).

For this reason the speed controller still needs to be adapted to the mass moment of inertia and rigidity of the mechanism. The adjustment described next should result in a good control response with the drive.

#### Determination of motor mass inertia (see also 4.5):

Set control mode to speed control (P 0300 = SCON)

Open Control/Commissioning/Autotuning subject area.
Set parameter **P 1517 SCD_AT_JsumCon** to Start(2) = start test signal and calculation. This calculates the mass inertia. When the calculation has been successfully made, the value for the mass inertia on the Motor screen must change.

#### Adaptation to the rigidity of the mechanism

Adaptation to the rigidity of the mechanism can be effected after calculating the mass moment of inertia **P 1516** by writing parameter **P 1515** for the rigidity of the control. By writing a percentage value the rigidity, and thus also the phase reserve of the speed control loop, is influenced.
Based on the rigidity set via **P 1515**, the mass moment of inertia and the filter time constant for the speed feedback P 0351, the PI speed controller
**P 0320, P 0321** and the P position controller **P 0360** are set. At the same time, the observer for a single-mass system is parameterized but not yet activated. Speed feedback still takes place via the delaying digital filter.

## 4.2 Current control/Torque controller

By optimizing the current controller it can be adapted to the special requirements of the drive task. For dynamic applications it is highly recommended to design the current controller as dynamically as possible with a short rise time. For noise-sensitive applications, a less dynamic setting with a longer rise time is recommended.

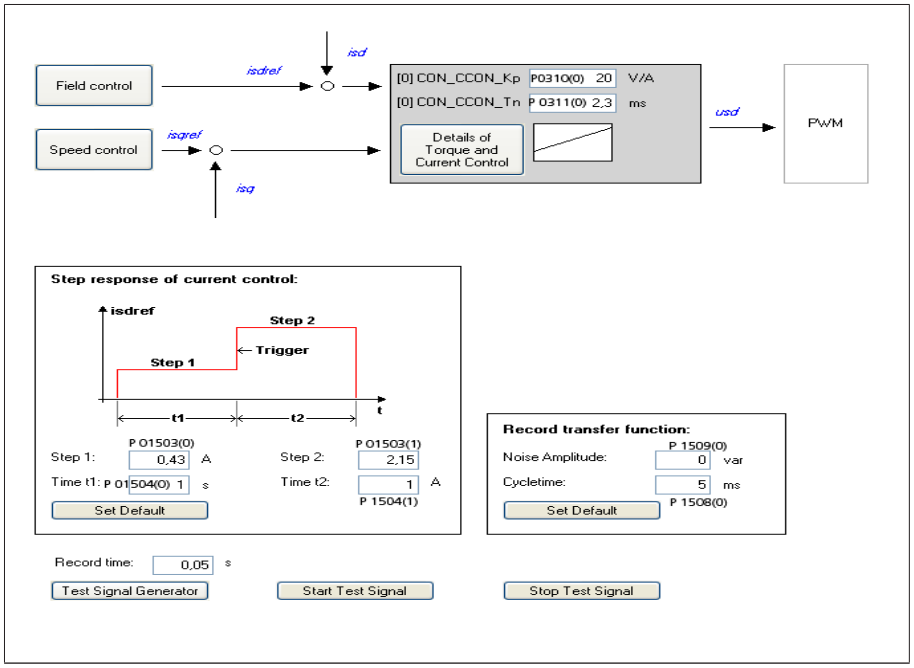



*Figure 4.4 Dialogue box for the current control loop*

## Current controller optimization

In order to optimize the current control loop, a stepped current reference "Step1" is injected for the time "Time1". In the process, the motion of the rotor results in a current output value "isd". With "Step2" a current reference step response is preset for the time "Time2". This should correspond to the rated current of the motor. The "Start Test Signal" button opens a dialogue box containing safety instruction before the step response can be generated. The necessary setting of the scope function is made automatically by the wizard. The time base can be set manually.

Step response to rated current:

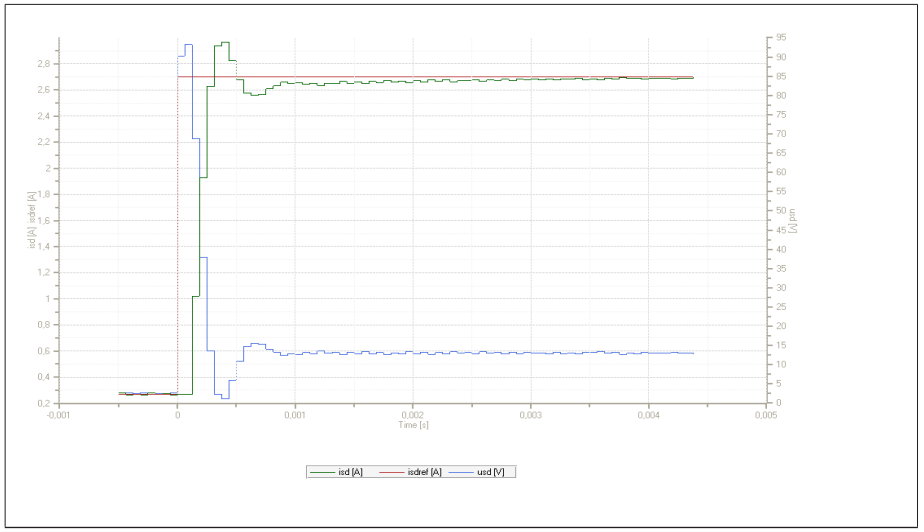



*Figure 4.5 Step up to rated current*

The faster the actual value approaches the setpoint (reference), the more dynamic is the controller setting. During settling, the overshoot of the actual value should be no more than 15 % of the reference setpoint.
The current controller can also be set by way of the test signal generator. This controller optimization method is described in more detail in section 4.5, Commissioning.

## Detent torque compensation/anti cogging

In order to compensate for detent torques (caused by non-sinusoidal EM curves), the torque-forming q-current is entered in a table and "taught-in" for one pole pitch division.

After elimination of the offsets (compensated table), the q-current is inverted and fed-in as the feed forward control value of the control (see figure 4.6). The compensation function can be described by means of compensating currents (q-current, scope signal isqref) dependent on a position (electrical angle, scope signal epsrs). A "teach-in" run imports the values into a table with 250 interpolation points. Parameter P 0382 CON_TCoggComp activates the function (ON/OFF).

## Teach

Teaching is controlled via parameter **P 0385 CON_TCoggTeachCon**. The teach procedure to determine the detent torque characteristic is as follows.

Run the motor at low speed (feed frequency < 0.1 Hz) in speed control mode, then write the control word **P 0385** to the value TeachTab1(1). The characteristic of the q-current is averaged by a special filter and recorded in the table values of parameter **P 0383 CON_TCoggTeach1**. Each table value should have been written at least once. The motor should thus have moved through several pole pitch divisions during teach mode. Then the control word **P 0385** is written to the value CalCorrTab(3). The recorded currents are filtered, a calculated offset is extracted and the result is written to the compensation table of parameter **P 0380 CON_TCoggAddTab**.

## Compensation

**P 0382 CON_TCoggComp** (ON/OFF)enables the compensation table. The interpolation between the table values is linear. The characteristic is not saved automatically; the SAVE command must be used.

The progress of the teach process and the compensation can be tracked on the scope. The signal isqCoggTeach indicates the current output value of the teach table during teach mode, while isqCoggAdapt contains the current value from the compensation table.

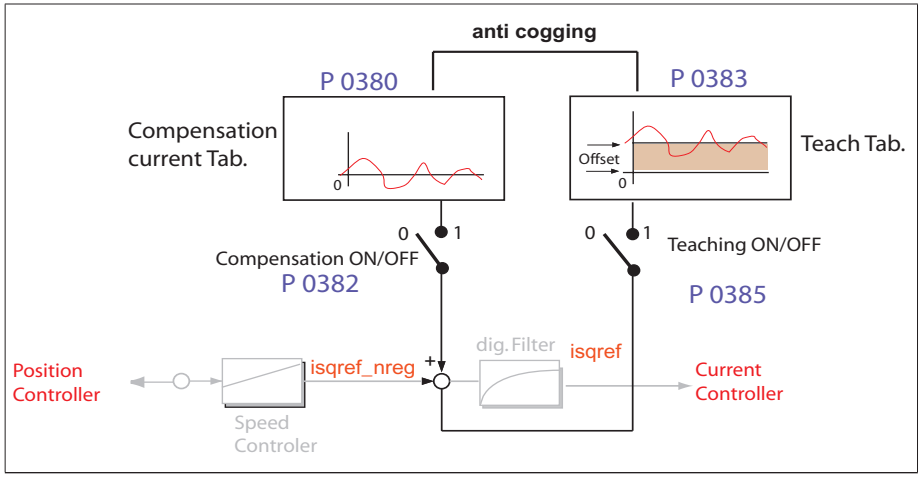



*Figure 4.6 Schematic for detent torque compensation*

The following parameters are available to activate this process:

| P. no. | Parameter name/ Settings | DM5 description | Function |
|---|---|---|---|
| P 0380 | CON_TCoggAddTab | Anti Cogging - compensation current table | Table with compensated values |
| P 0382 | CON_TCoggComb | Anti Cogging - compensation on/off | Compensated table values are imported into the control |
| P 0383 | CON_TCoggTeach1 | Anti Cogging - recorded currents at teaching | The characteristic of the q-current is averaged by a special filter and imported into the table of parameter **P 0383 CON_TCoggTeach1**. |
| P 0385 | CON_TCoggTeachCon | Anti Cogging - teach control word | Start of teach function to fill table |

## 4.2.1 Advanced torque control

There are additional functions to improve the control performance of current and speed controllers. Here the **>Limitation**, **>Gain Scheduling**, and **>Observer** functions are described.

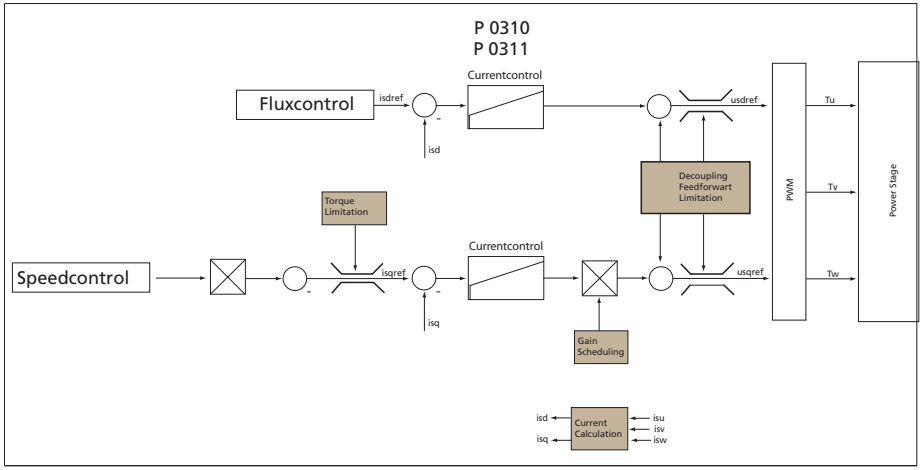



*Figure 4.7 Structure diagram of current and speed control*

### Limitation

Limitation of the voltage components usqref and usdref.
This also enables so-called overmodulation (limitation to hexagon instead of circle) in order to make better use of the inverter voltage.

| P. no. | Parameter name/ Settings | Description in DM 5 | Function |
|---|---|---|---|
| P 0432 | CON_CCONMode | select current control / limitation mode | Voltage limitation of $us_{q,ref}$ and $us_{d,ref}$. |
| (0) | PRIO(0) | Hard-Change-over of priority | Hard switch from d-priority (motorized) to q-priority (regenerative) |
| (1) | PRIO_RES(1) | Priority with reserve (CON_CCON_VLimit) | Expert mode: Switch from d-priority (motorized) to q-priority (regenerative). A portion of the voltage is held in reserve; the amount can be specified via parameter P 0431 CON:CCON_VLimit. |
| (2) | Phase(2) | CON_CCONOV_Mode:Phase | Phase-correct limitation |
| (3) | HEX_PHASE (3) | Hexagon modulation, limitation with correct phase angle | Hexagon modulation with phase-correct limitation. More voltage is available for the motor. The current exhibits a higher ripple at high voltages however. |

## Adaptation of current control/gain scheduling

In the high overload range, saturation effects reduce the inductance of many motors. Consequently, the current controller optimized to the rated current may oscillate or become unstable.
As a remedy, it can be adapted to the degree of magnetic saturation of the motor. The gain of the current controller can be adapted to the load case over 4 interpolation points.

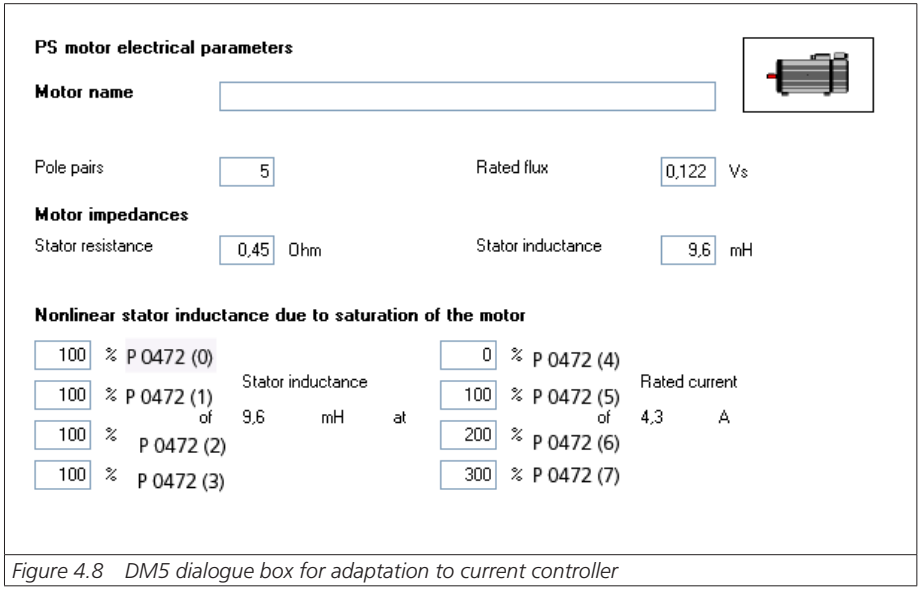



*Figure 4.8 DM5 dialogue box for adaptation to current controller*

In the lower area of the screen the values for the interpolation points are entered. On the left are the inductance values, and on the right the values for the overload ( > 100% of rated current) (see figure 4.8).

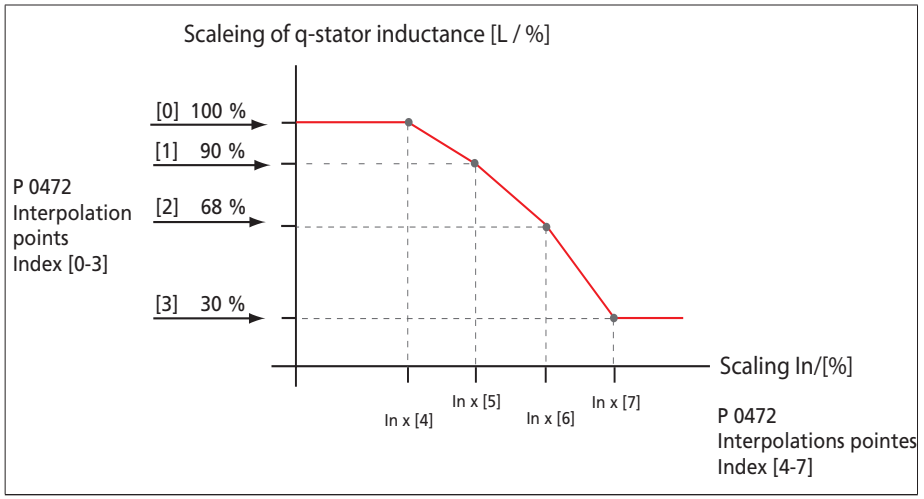



*Figure 4.9 Example of current control adaptation*

| P. no. | Parameter name/ Settings | Description in DM 5 | Function |
|---|---|---|---|
| P 0472 | MOT_LsigDiff | q-Stator inductance variation in % of MOT_Lsig | Scaling of q-stator inductance |
| 0-3 | 100% | Lsig_q 0-3 | Scaling of q-stator inductance in [%]; interpolation points [0-3] |
| 4-7 | 100% | Current 0-3 | Scaling of rated motor current in [%]. Interpolation points [4-7] |

Note: Between the interpolation points the scaling factor is interpolated in linear mode. The current scaling of the inductance is plotted in the scope variable “Is_ActVal_under Control, Flux Model”.

### **Observer**, Current calculation

To increase the current control dynamics and reduce the tendency to oscillation, there is a so-called observer. It predicts the current.

| P. no. | Parameter name/ Settings | Designation in DM 5 | Function |
|---|---|---|---|
| P 0433 | CON_CCON_ObsMod | Select current observer mode | Switching the observer on and off for current control |
| (0) | OFF(0) | Observer not used | |
| (1) | Time Const(1) | Use observer design acc. time contant | The currents determined from the observer are used for the motor control. The configuration is based on setting of a filter time constant in **P 0434, Index 0** |
| (2) | Direct(2) | Use observer preset of Kp and Tn | Direct parameterization of the observer feedback via P 0434 index 1 (KP) and 2 (Tn) |

## 4.3 Speed control

If the motion range is not limited, it is advisable to optimize the speed controller by means of step responses. In this, the motor model must be adapted precisely to the individual motor. In the standard motor data set the speed controller is preset for a moderately stiff mechanism.
The speed controller may need to be adapted to the moment of inertia and the rigidity of the mechanism (see Control section, “Adaptation to the mechanism”).

Note:

| | |
|---|---|
| Low value for the actual speed value filter | High control dynamics |
| High value for the actual speed value filter | Control dynamics decreases, smooth running quality increases |

The dialogue box (figure 4.10) can be used to set the control parameters of the speed controller:

- Gain
- Lag time
- Gain scaling
- Filter time
- Speed limitation

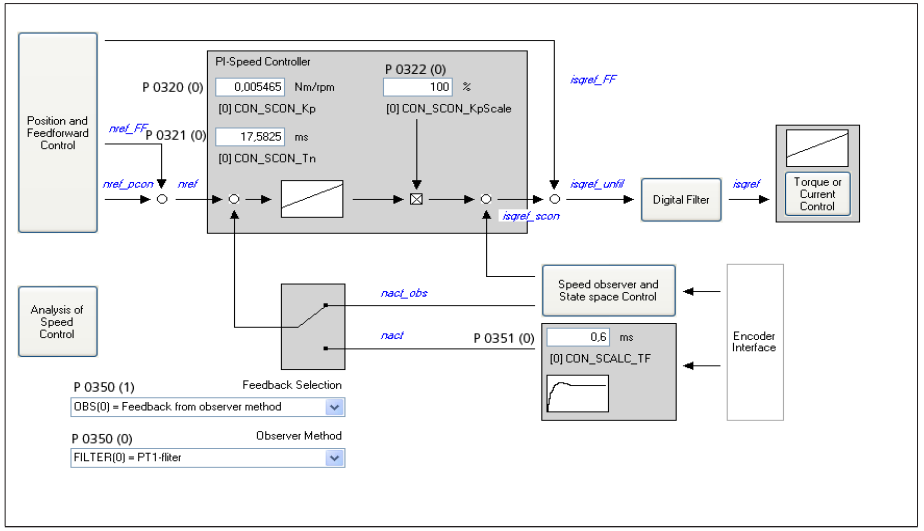



*Figure 4.10 Speed controller screen*

All parameters take effect online, though only the scaling parameter **P 0322** is transferred in defined real time (with speed controller sampling time).

So setting the gain via the scaling parameter **P 0322** is useful for the following reasons:

- With this the gain can be adapted via the field bus or an internal PLC to respond to a variable mass moment of inertia.
- By selecting the scaling there is always a refer-back to the reference setting of 100%.

## Speed controller optimization by step responses

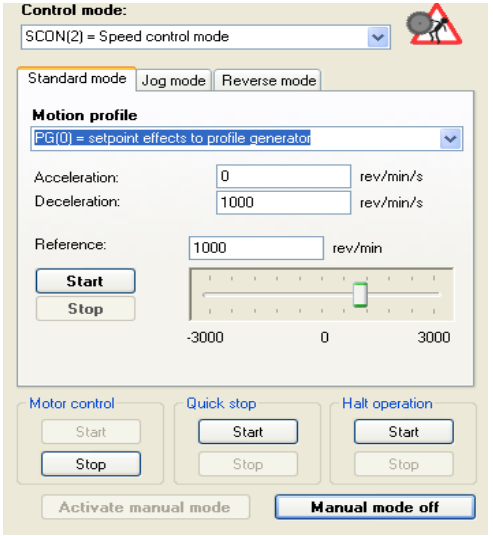
To activate step responses the controller should be operated in speed control mode "SCON". For this purpose please set the parameters in the following list to the specified values and use parameter **P 0402 CON_SCON_AddSRef** to adjust the step height of the speed reference.

The important factor here is that the speed controller shows low-level signal response, which means that the q-current reference does not reach the limitation during the step. This can be easily identified by its constant value over a certain time during the acceleration phase. In this case either the maximum torque **P 0329 CON SCON_TMax Tmax** must be increased or the height of the reference step **P 0402** reduced.

| P. no. | Parameter name/ Settings | Description with DM 5 | Function |
|---|---|---|---|
| P 0165 | MPRO_REF_SEL | TAB(3) = via table | Selection of reference source |
| P 0300 | CON_Cfg_Con | SCON(2) | Speed control activated |
| P 0320 | CON_SCON_Kp | | Speed controller gain |
| P 0321 | CON_SCON_Tn | | Speed controller lag time |
| P 0322 | CON_SCON_KpScale | 100 % | Gain scaling |
| P 0328 | CON_SCON_SMax | | Speed limitation |
| P 0351 | CON_SCALC_TF | Recommended setting: 0.6 to 1.2 ms | Actual value filter |
| P 0402 | CON_SCON_AddSRef | Value | Speed reference |

## Speed controller optimization:

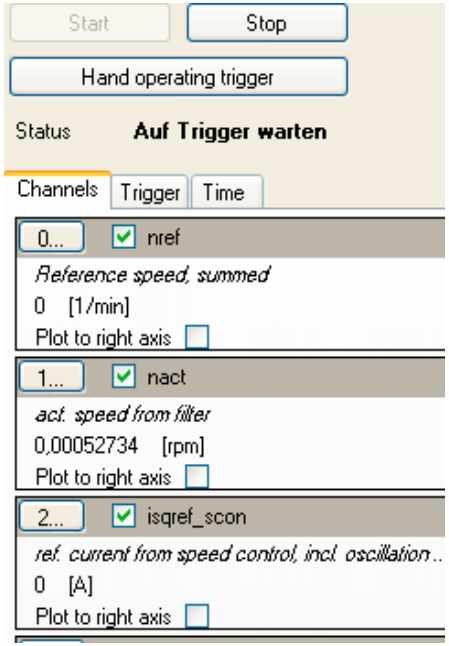
The reference steps necessary for optimization can be executed in a user-friendly way by way of the Control window. This requires the following settings:




Open Control window

Make settings:
- Control mode
  Speed-controlled **(SCON)**
- **no ramps: Acceleration ramp = 0**

*Figure 4.11 Speed controller optimization*




Open scope:
Setting:

**Channel:**
CH 0 = speed reference (nref)
CH 1 = actual speed (nact)
CH 2 = actual torque (mact)

**Trigger:**
Trigger signal: Speed reference (nref)
Mode: Rising edge
Level: 30 rpm
Pretrigger: 0 %

**Time:**
Sampling time: = base time (6.25E-0.5 s)
Recording time = 0.2 s

*Figure 4.11 Speed controller optimization*

*Figure 4.11 Speed controller optimization*

This graph (figure 4.11) shows a typical speed step response with a rise time of 14 ms and an overshoot amplitude of 15 %.

The reference of the q-current must not reach the limit during the step. This can be easily identified by its assuming a constant value over a certain time during the acceleration phase. In this case either the maximum torque **P 0329 CON SCON_TMax Tmax** must be increased or the level of the reference reduced.

To set the speed controller gain the **P 0322 CON_SCON_KpScale** can be used. The default setting of this parameter is 100 %. If this parameter is changed in order to set the gain, the deviation of the setting from the default is precisely known.

Note:

| | |
|---|---|
| Hard controller setup | High control dynamics,<br>smooth running quality decreases |
| Soft controller setup | Control dynamics decreases,<br>smooth running quality increases |

## 4.3.1 Digital filter

To suppress potential disturbance frequencies (resonances) which might cause a system to oscillate, it is possible to activate different filter types.

For this, a general digital filter with the following time-discrete transfer function is implemented in the forward branch of the speed controller (figure 4.1):

- y(k) = B(4)*x(k-4)+ B(3)*x(k-3)+ B(2)*x(k-2) + B(1)*x(k-1) + B(0)*x(k)
  - A(4)*x(k-4)+ A(3)*x(k-3)+ A(2)*y(k-2) - A(1)*y(k-1)

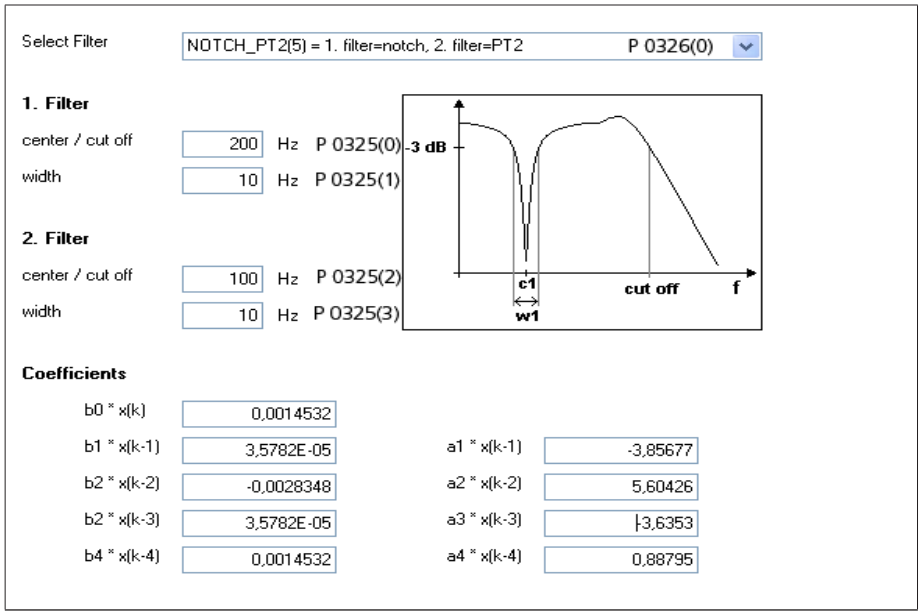



*Figure 4.12 Dialogue box for setting the digital filters*

With the notch filter **P 0326 CON_SCON_FilterAssi**it is possible to suppress defined unwanted frequencies. The blocking frequency and bandwidth are required for this.
When writing the parameter, the corresponding coefficients of the transfer function in **P 0327** are changed.
For parameterization of standard filters, field parameter **P 0325 CON_SCON_FilterReq** is provided to specify limit frequencies and bandwidths.

Settings for assistance parameter **P 0326 CON_SCON_FilterAssi:**

| P. no. | Parameter name/ Settings | Description in DM 5 | Function |
|---|---|---|---|
| P 0325 | CON_SCON_FilterFreq | filter frequencies of digital filter | Limit frequencies |
| (0) | 1 - 8000 Hz | 1 st center/cutoff | 1. Mid/blocking frequency |
| (1) | 1 - 1000 Hz | 1 st width | Width |
| (2) | 1 - 8000 Hz | 2 nd center/cutoff | 2. Mid/blocking frequency |
| (3) | 1 - 1000 Hu | 2 nd width | Width |
| P 0326 | CON_SCON_FilterAssi | Digital filter calculation wizard | |
| (0) | OFF(0) | Reset & switch off filter | No filter active |
| (1) | USER(1) | direct (write parameter CON_ DigFilCoeff) | |
| (2) | Notch(2) | 1. filter=notch, 2. filter=OFF | A notch filter with blocking frequency in **P 0325(0)** and bandwidth in **P 0325(1)**. |
| (3) | NOTCH_NOTCH(3) | 1. filter=notch, 2. filter=notch | A notch filter with blocking frequency in **P 0325(0)** and bandwidth in **P 0325(1)** in series with a notch filter with blocking frequency in **P 0325(2)** and bandwidth in **P 0325(3)** |
| (4) | NOTCH_PT1(4) | 1. filter=notch, 2. filter=PT1 | NOTCH_PT1(4) and NOTCH_PT2(5): A notch filter with the blocking frequency in **P 0325(0)** and bandwidth in **P 0325(1)** in series with a low-pass filter with limit frequency in **P 0325(2)**. |
| (5) | NOTCH_PT2(5) | 1. filter=notch, 2. filter=PT2 | |
| (6) | PT1(6) | 1. filter=OFF, 2. filter=PT1 | PT1(6), PT2(7), PT3(8), PT4(9): A low-pass filter with the limit frequency in **P 0325(2)** At lower frequencies higher-order filters (PT3, PT4) should not be used. |
| (7) | PT2(7) | 1. filter=OFF, 2. filter=PT2 | |
| (8) | PT3(8) | 1. filter=OFF, 2. filter=PT3 | |
| (9) | PT4(9) | 1. filter=OFF, 2. filter=PT4 | |
| P 0327 | CON_SCON_FilterPara | coefficients of digital filter | Coefficients of the digital filter |
| (0) | | a0*x(k) | |
| (1) | USER | a1*x(k-1) | |
| (2) | USER | a2*x(k-2) | |
| (3) | USER | a3*x(k-3) | |
| (4) | USER | a4*x(k-4) | |
| (5) | USER | b1*y(k-1 | |
| (6) | USER | b2*y(k-2) | |
| (7) | USER | b3*y(k-3) | |
| (8) | USER | b4*y(k-4) | |

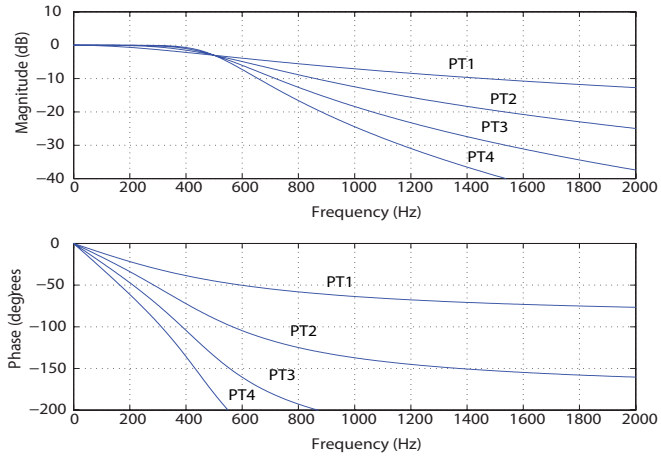



*Figure 4.13 Frequency responses of PT1, PT2, PT3, PT4 filters*

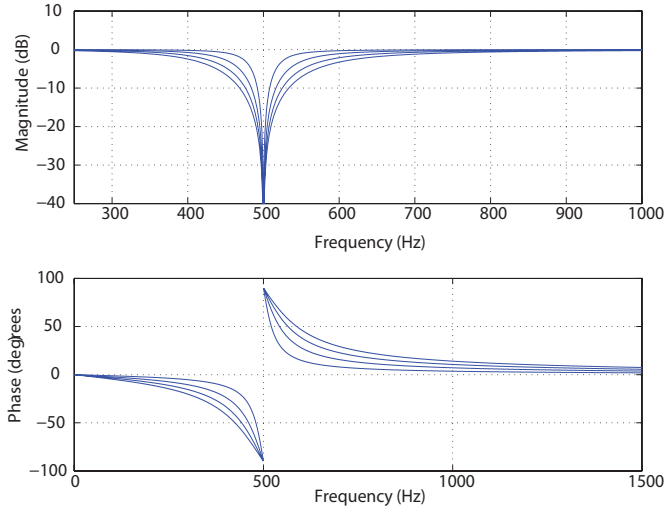



*Figure 4.14 Notch filter: Blocking frequency 500 Hz and bandwidths 25, 50, 75 and 100 Hz*

Note that the filters not only influence the amount, but also the phase, of the frequency response. At lower frequencies higher-order filters (PT3, PT4) should not be used, as the phase within the control bandwidth is negatively influenced.

Note: The coefficients can also be specified directly via parameter **P 0327 CON_SCON_FilterPara**. They take effect directly, so changing them is only recommended when the control is switched off.

Procedure:

1. **Scope setting:**
   isq (unfiltered, torque-forming current)
   Set shortest sampling time
   Create **scope plot** without filtering
2. Click **"Mathematical functions" > FFT** (Fourier analysis) icon. From the following pop-up menu choose isq. Disturbance frequency is displayed.
3. **Select filter:** Select filter
4. **center/cut-off:** Enter disturbance frequency
5. **width:** Enter the bandwidth of the disturbance frequency; the width has no effect when using PTx filters
6. Create **Scope plot** with filtering

Note: A higher bandwidth results in less attenuation of the blocking frequency because of the filter structure.
**(Filter as little as possible but as much as necessary)**

Oscillation of a motor shaft at speed zero:

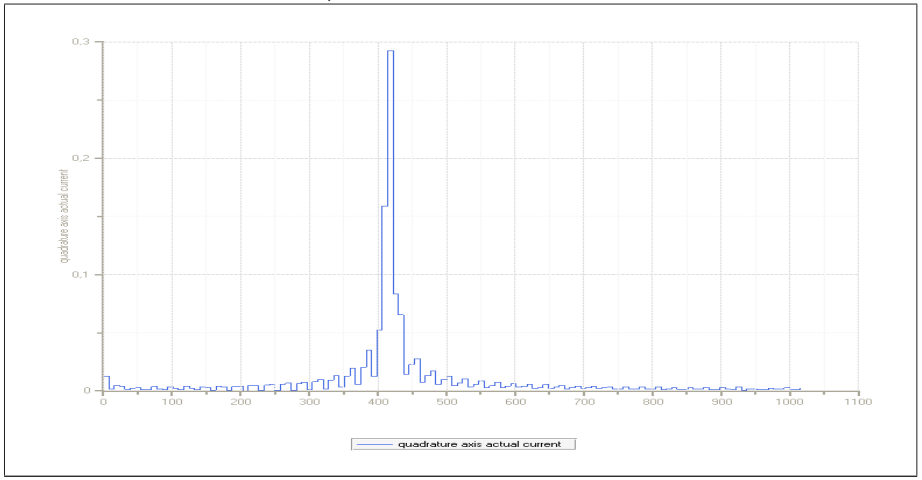



*Figure 4.15 Oscillation of a motor shaft under current at standstill without filter*

Oscillation suppression by a notch filter:

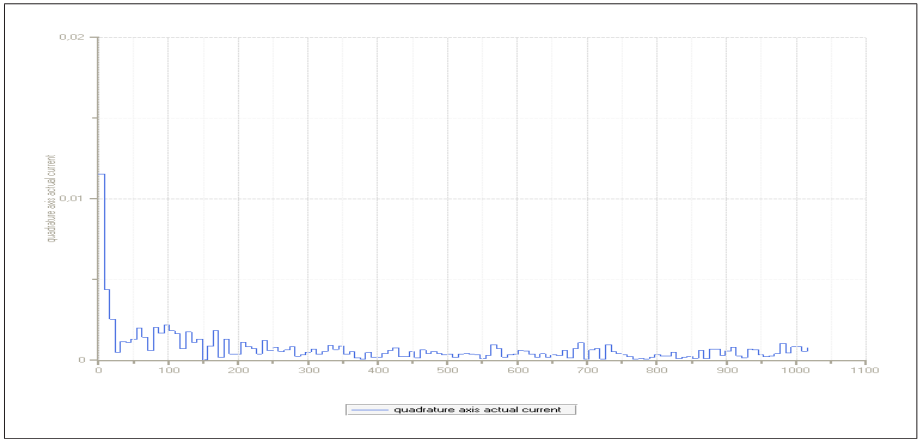



*Figure 4.16 Motor shaft under current at standstill with activated notch filter (width f=40Hz, mid-frequency f= 420 Hz)*

## Speed controller gain reduction at low speeds

To avoid standstill oscillations with a simultaneously highly dynamic speed control setting during a short positioning cycle, the speed control gain can be adapted at “low speeds” or “speed zero” (especially effective with TTL encoders).

- Speed gain reduction at low speeds
- prevents “buzzing” or cogging (especially effective for TTL encoders)

The configuration is set by a parameter **P 0336**.

| P. no. | Parameter name/ Settings | Designation in DM5 | Function |
|---|---|---|---|
| P 0336 | CON_SCON_KpScaleSpeedZero | Adaptation of speed control gain @ zero speed | Reduction of speed controller gain at low speeds or speed 0 |
| (0) | Index 0 in [%] | gain for low/zero speed | Weighting of the speed controller gain reduction in percent |
| (1) | Index 1 [Rpm] | definition of the speed limit to detect zero speed | Weighting of the speed controller gain reduction in rpm |
| (2) | Index 2 [ms] | filter time for change from zero to higher speed | Filter time for the speed transition from 0 to $n_{max}$ |
| (3) | Index 3 [ms] | filter time for change from higher to zero speed filter time for change from higher to zero speed | Filter time for the speed transition from $n_{max}$ to 0 |

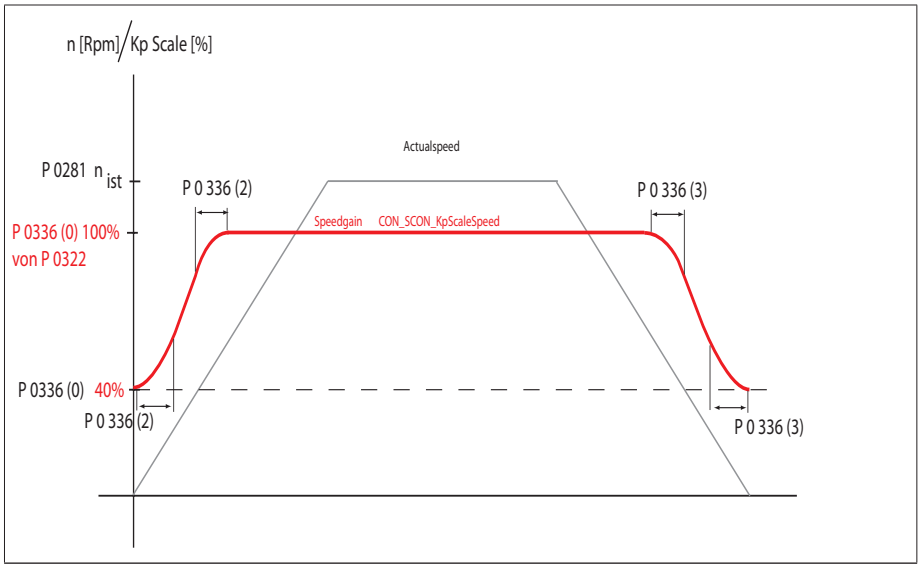



*Figure 4.17 Speed controller gain reduction*

## Single-mass observer to determine actual speed value

With the single-mass system observer the phase shift over time caused by the jitter filter can be reduced in the feedback branch, thereby considerably enhancing the speed controller performance.

During basic setting of the speed controller by means of the calculation assistant **P 1515 SCD_ConDesign** a single-mass system observer with medium dynamism has already been calculated.

The observation algorithms are calculated as soon as the selector **P 0350 Index 1** is set to "Filter(1)". The PT1 filter and the selected observer type are then calculated in parallel.

Feedback via the PT1 filter or via the observer can then be toggled by the selector **P 0350 Index 1**.

Observer optimization:

1. The mass moment of inertia must be determined correctly.
2. The dynamism is set via the equivalent time constant **P 0353-Index 0**, which behaves in a similar way to the actual speed filter time constant: Increasing the time constant enhances the noise suppression, but also reduces the dynamics.
3. By writing the calculation assistant **P 0354 = Def** the observer is reconfigured. This change takes effect online.
4. An optimization can be made iteratively (in steps) by adapting the equivalent time constant, linked with rewriting of the calculation assistant.

Parameter

| P. no. | Parameter name/ Settings | Designation in DM5 | Function |
|---|---|---|---|
| P 0350 | CON_SCALC_SEL | Selection of Speed calculation method | Selection of speed calculation method |
| (0) | SEL_ObserverMethod | " | " |
| | Filter(0) | PT-Filter | Signal from observer system; actual value filter activated |
| | OBS1(1) | One mass observer | Single-mass observer |
| | OBSACC(2) | Observer with acceleration sensor | Observer with acceleration sensor |
| | OBS2(3) | Two mass observer | Dual-mass observer |
| (1) | SEL_FeedbackMethod | | |
| | OBS(0) | Feedback from Observer method | |
| | Filter(1) | Feedback from Filter | |
| P 0353 | CON_SCALC_Obs DesignPara | Observer design parameters | Equivalent time constant of observer |
| (0) | TF | Time constant of observer | Time constant 1 ms |
| 1 | Alpha | Damping coefficient | |

| P. no. | Parameter name/ Settings | Designation in DM5 | Function |
|---|---|---|---|
| 2 | Load point | Load torque is applied | as from V 2.0 |
| 3 | TF1 | Time constant of speed filtering | as from V 2.0 |
| 4 | TF2 | Time constant of load torque adaption | as from V 2.0 |
| 5 | TFosc | Time constant of oscillation adaption | as from V 2.0 |
| 6 | AccGain | Acceleration measurement gain | as from V 2.0 |
| P 0354 | CON_SCALC_ObsDe-signAssi | Observer design assistent | Calculation wizard for observer |
| 0 | USER | User definied design | as from V 2.0 |
| 1 | DEF | Default design for selected observer | Start calculation with default design rule |
| 2 | DR | Observer design by double ration | as from V 2.0 |
| 3 | TIMES | Observer design by time constant | as from V 2.0 |

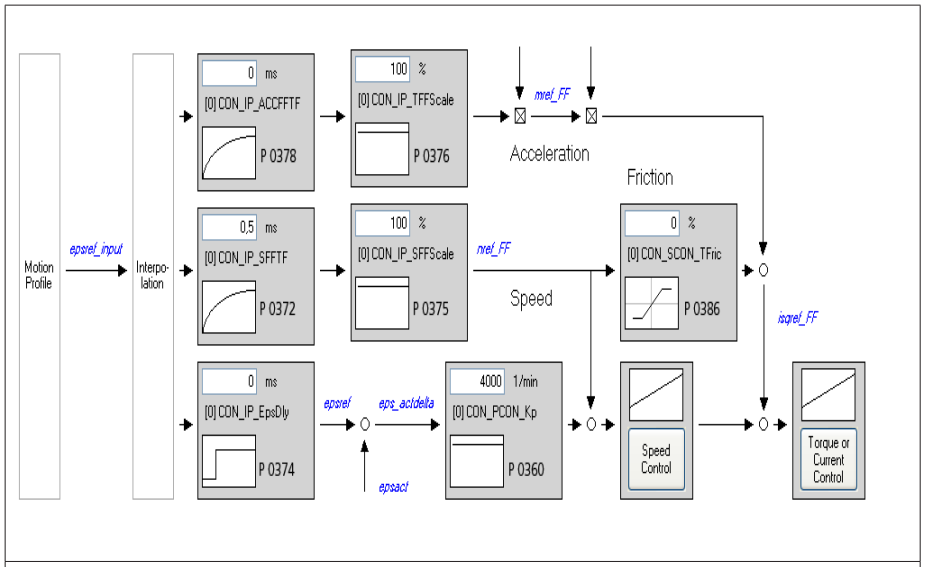



*Figure 4.18 Position controller setup screen*

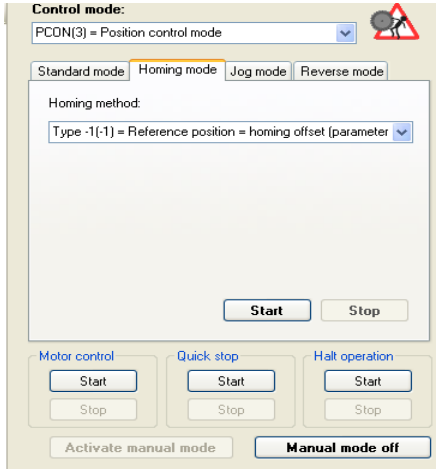
## 4.4 Position control

The higher the dynamics of the speed controller, the more dynamically the position controller can be set and the tracking error minimized. In order to improve the dynamics and performance of the position controller, the parameters listed in the bottom screen are available to optimize the speed and acceleration feed forward control.

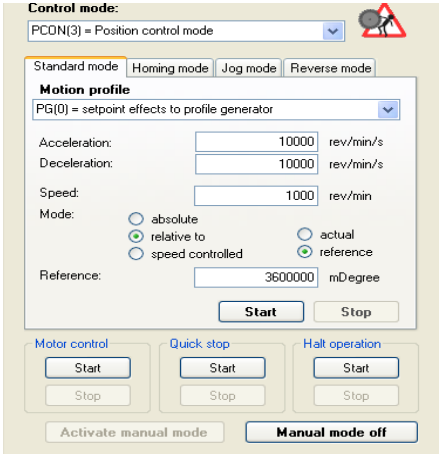
## Position controller optimization::

The reference values for the necessary setpoint steps for controller optimization can be easily preset by way of a reference table or the Control window (see also “Motion profile” section).

### Reference via Control window

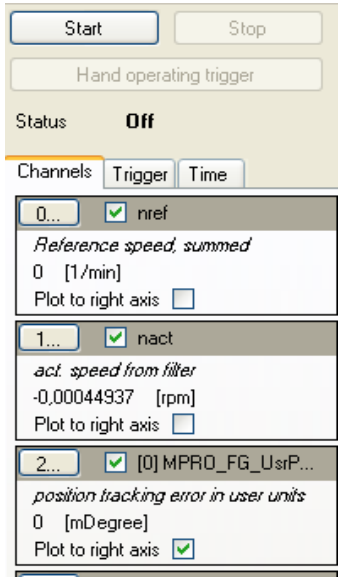



- Select control mode “PCON”
- Homing method -1. Type -1 sets the current position as the zero.
- Start the power stage via “START” (motion control)
- Start/stop homing mode




- Select standard mode
- Set ramps
- Set position reference
- Activate scope function (see Scope screen)
- Start motion

*Figure 4.19 Setting for Control window and scope in position controller optimization*




Open scope:
Setting:

**Channel:**
CH 0 = speed reference
(6 nref)
CH 1 = actual speed
(13 nact)
CH 2 = tracking error in user units
(279 UsrPosDiff)

**Trigger:**
Trigger signal: Speed reference (6 nref)
Mode: Rising edge
Level: 30 rpm
Pretrigger: 10 %

**Time:**
Sampling time: = Base time
(6.25E-0.5 s)
Recording time = 1.0 s

*Figure 4.19 Setting for Control window and scope in position controller optimization*

## The position controller gain:

When a standard motor data set is read-in, the control setting is also adopted. The setting equates to a controller with a medium rigidity.

Note: In the default setting no smoothing is selected!

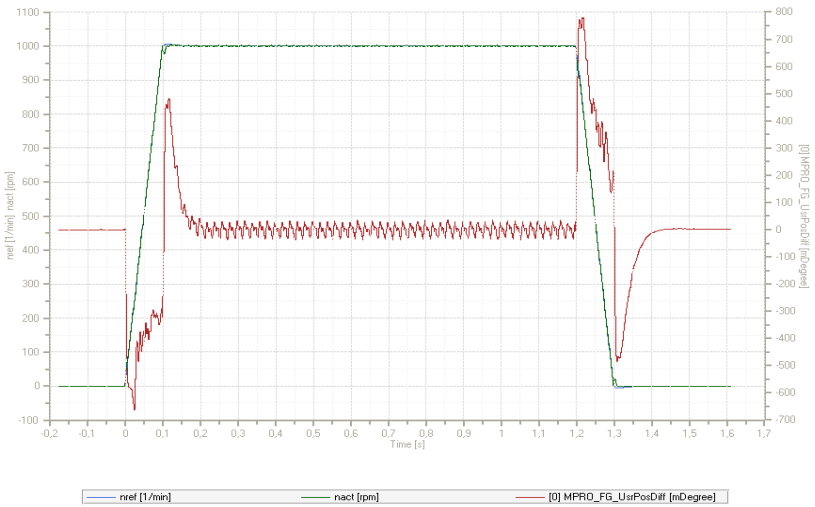
The following graphs show optimization of the position control of a synchronous machine.

**The dimensioning of the tracking error 279 MPRO_FG_UsrPosDiff is on the right-side y axis. A changed variable relative to the previous graph is highlighted in brown in the value table.**

The step responses show the controller setting with:

- increased gain factor (P-component) with smoothing
- influence of feed forward control

Controller with medium rigidity (KP = 4000).



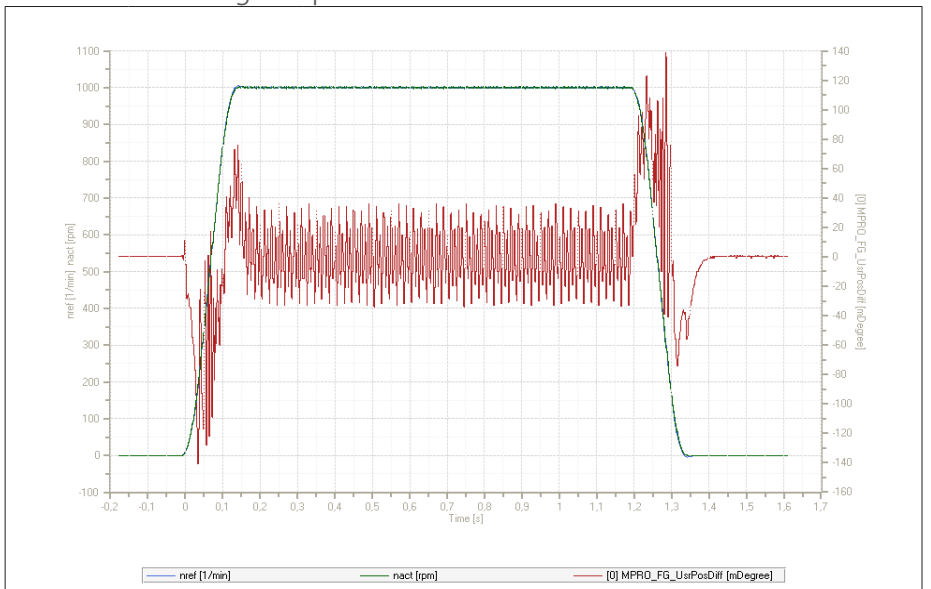

| P. no. | Value | Function |
|---|---|---|
| P 0351 | 1.2 | Speed controller filter time |
| P 0360 | 4000 | Position control gain |
| P 0372 | 0.5 ms | Filter time for position controller feed forward control |
| P 0374 | 0 ms | Delay time for position control feed forward control |

*Figure 4.20 Position gain after read-in of a standard motor data set*

| | | |
|---|---|---|
| P 0375 | 100 % | Speed control feed forward control scaling factor |
| P 0376 | 100 % | Torque control feed forward control scaling factor |
| P 0386 | 0 % | Compensation of friction torques |
| P 1516 | 0.00014 kgm² | Mass inertia |
| P 0166 | 0 ms | Filter time |

*Figure 4.20 Position gain after read-in of a standard motor data set*

## Position controller gain optimization




| P. no. | Value | Function |
|---|---|---|
| P 0351 | 1.2 ms | Actual speed filter time |
| P 0360 | 30000 | Position controller gain |

*Figure 4.21 Optimized position gain: Typical values for the position controller gain are between 10000 and 40000 rpm.*

| | | |
|---|---|---|
| P 0372 | 0.5 ms | Filter time for position controller feed forward control |
| P 0374 | 0 ms | Delay time for position control feed forward control |
| P 0375 | 100 % | Speed control feed forward control scaling factor |
| P 0376 | 100 % | Torque control feed forward control scaling factor |
| P 0386 | 0 % | Compensation of friction torques |
| P 1516 | 0.00014kgm² | Mass inertia |
| P 0166 | 50 ms | Filter time |

*Figure 4.21 Optimized position gain: Typical values for the position controller gain are between 10000 and 40000 rpm.*

## 4.4.1 Feed forward control of speed, torque/force

The feed forward control of the acceleration torque relieves the strain on the speed controller and optimizes the control response of the drive. To feed forward control the acceleration torque, the mass inertia reduced to the motor shaft must be known.

If the parameter for the overall mass inertia of the system **P 1516** has a value unequal to 0, that value will be automatically used to feed forward control the acceleration torque.

The feed forward control of the speed reference is preset by default to 100 % via parameter
**P 0375 CON_IP_SFF_Scale**. This value should not be changed.

The acceleration torque feed forward control can be optimized with **P 0376 CON_IP_TFF_Scale**.
Reducing this reduces the feed forward control value; conversely, increasing this value also increases the feed forward control value.

The position tracking error can be further reduced by predictive torque and speed feed forward control, i.e. in advance of the position referencing. Owing to the time-discrete mode of operation of the control circuits and the limited dynamics of the current control circuit, this prediction is necessary to prevent the individual control circuits from oscillating against one another. Prediction in feed forward control is achieved by delaying the speed and position controller reference setpoints. Delay parameter:

Feed forward control parameters:

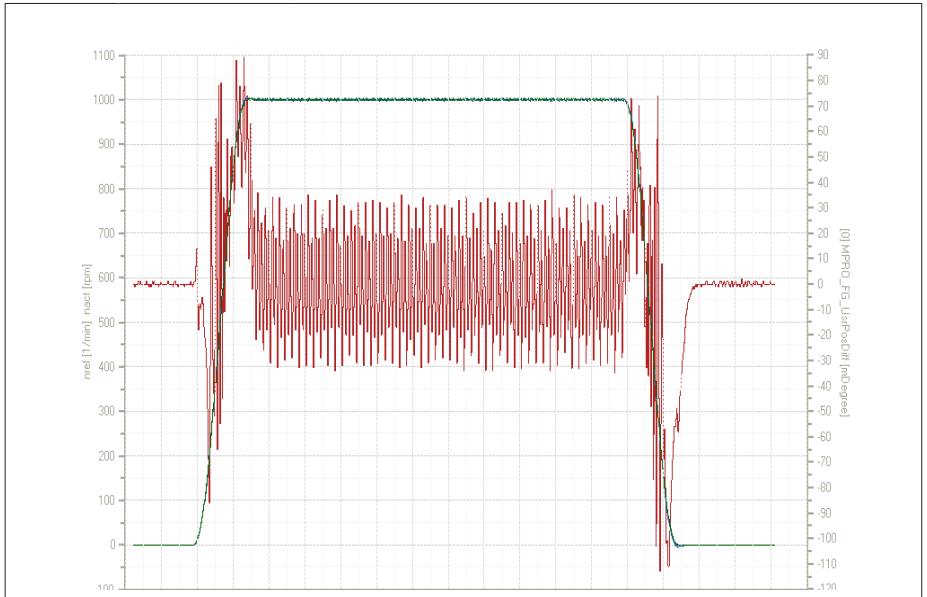
| P. no. | Parameter name/ Settings | Designation in DM5 | Function |
|---|---|---|---|
| P 0360 | CON_PCON_KP | Position control gain | Gain of position controller |
| P 0372 | CON_IP_SFFTF | Speed feedforward filter time for position control | Filter time for position controller feed forward control |
| P 0374 | CON_IP_EpsDly | Position delay time | Delay time for position control feed forward control |
| P 0375 | CON_IP_SFFScale | Speed feedforward scaling factor | Speed control feed forward control scaling factor |
| P 0376 | CON_IP_TFFScale | Torque/Force feedforward scaling factor | Torque control feed forward control scaling factor |
| P 0378 | CON_IP_ACC_FFTF | Acceleration feed forward filter time | Filter time for acceleration feed forward control |
| P 0386 | CON_SCON_TFric | friction compensation scaling factor | Scaling factor for friction compensation |
| P 1516 | SCD_Jsum | Total inertia of motor and plant | Reduced mass inertia of motor and machine |

Attention: The feed forward control does not take effect if the control reaches the set limits because the ramp setting is too steep.

Note: The overall mass moment of inertia in P 1516 must not be changed to optimize the feed forward control, because this would also have an effect on other controller settings!

The value in **P 0372 CON_IP_SFFFT** for the PT1 filter to delay the speed feed forward control value should be chosen slightly larger than the value for the actual speed value filter **P 0351 CON SCALC_TF**.
Useful values for floating mean value filters to delay the position reference setpoint are between 0.0625 ms and 1.5 ms. The following graph shows a driving profile with feed forward control prediction:

Attention: In multi-axis applications requiring precise three-dimensional axis coordination, such as in the case of machine tools, the delay of the position signal must be equally set on all axes via parameter **P 0374-IP_EpsDly**. Otherwise the synchronization of the axes may suffer, leading to three-dimensional path errors.
**When using linear interpolation feed forward control is inactive.**



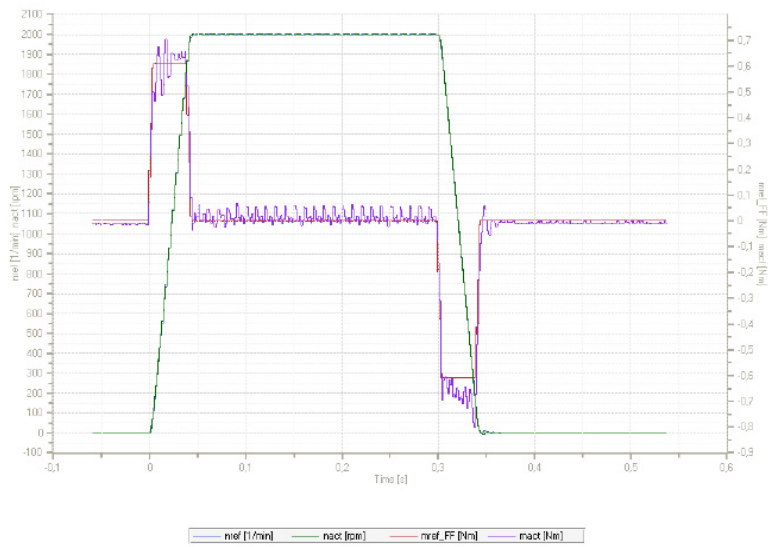

| P-Nr. | Wert | Funktion |
|---|---|---|
| P 0351 | 1.2 ms | Speed controller filter time |
| P 0360 | 30000 | Position controller gain |
| P 0372 | 1.2 ms | Filter time for position controller feed forward control |
| P 0374 | 0.125 ms | Delay time for position control feed forward control |
| P 0375 | 100 % | Speed control feed forward control scaling factor |
| P 0376 | 100 % | Torque control feed forward control scaling factor |
| P 0386 | 0 % | Compensation of friction torques |
| P 1516 | 0.00014 kgm² | Mass inertia |
| P 0166 | 50 ms | Smoothing |

*Figure 4.22 Driving profile with feed forward control*

### Friction

It is advisable to compensate for higher friction torques in order to minimize tracking error when reversing the speed of the axis. The drive controller permits compensation for Coulomb friction components by means of a signum function dependent on the reference speed **"nref_FF"**. The speed controller can compensate for the other (e.g. viscous) friction components because of their lower change dynamics. The compensation can be effected step-by-step as a percentage of the rated motor torque by means of **P 386 CON_SCON_TFric**.

The following graph shows a good match between the feed forward control torque reference and the actual torque value.




| P. no. | Value | Function |
|---|---|---|
| P 0351 | 1.2 ms | Speed controller filter time |
| P 0360 | 30000 | Position controller gain |
| P 0372 | 1.2 ms | Filter time for position controller feed forward control |
| P 0374 | 0.125 ms | Delay time for position control feed forward control |
| P 0375 | 100 % | Speed control feed forward control scaling factor |
| P 0376 | 100 % | Torque control feed forward control scaling factor |
| P 0386 | 6 % | Compensation of friction torques |
| P 1516 | 0.00014 kgm² | Mass inertia |

*Figure 4.23 Graph of feed forward control torque reference and actual torque value*

## 4.4.2 Field-weakening mode

### Field-weakening for asynchronous motors

For field-weakening of asynchronous motors, the motor parameters must be known very precisely. This applies in particular to the dependency of the main inductance on the magnetizing current.

In the process, default values for the control circuits and the "magnetic operating point" are set based on the rated motor data and the magnetizing current presetting in **P340 CON_FM_Imag**. A range of different methods are available for operation in field-weakening mode.

# Field weakening for Asynchronous motor

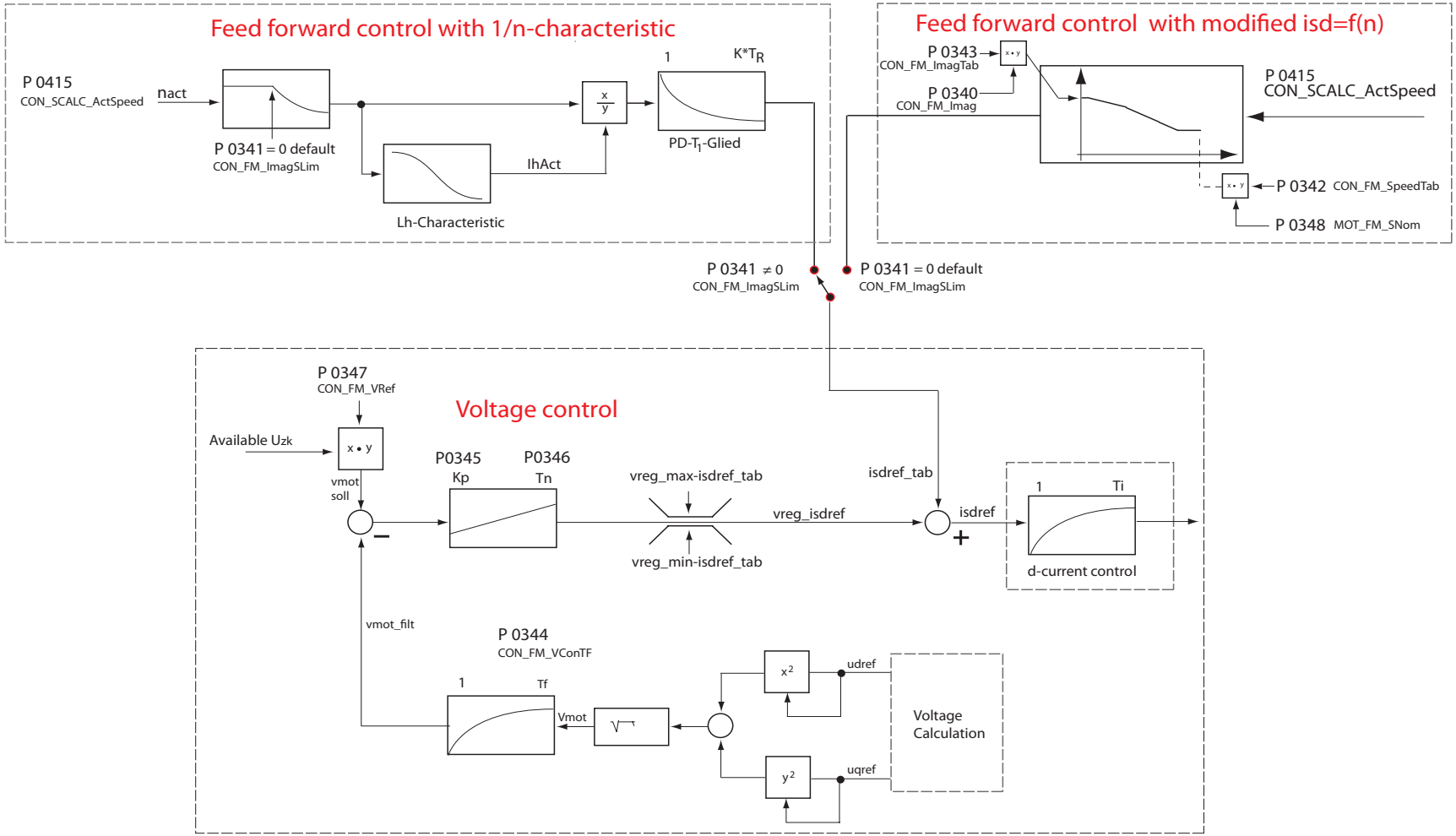



*Figure 4.24 Asynchronous machine field-weakening*

One method involves voltage regulation with feed forward control by way of a **1/n characteristic**. The motor identification sets the voltage regulator so that the voltage supply in a weakened field is adequate. If the drive controller is at the voltage limit, it reduces the d-current and thus the rotor flux. Since the controller has only limited dynamism, and starts to oscillate if larger gain factors are set, there is a second option. The voltage regulation combines with the feed forward control by way of a freely definable characteristic (modified 1/n characteristic) which describes the magnetizing current as a percentage of the nominal value of **P 0340 CON_FM_Imag** dependent on the speed.

The choice between the 1/n characteristic and the static characteristic is based on parameter **P 0341 CON_FM_ImagSLim**. If **P 0341** becomes zero, the static characteristic is evaluated. If the parameter is unequal to zero, the flux is routed along a 1/n characteristic as from the speed ImagSLim.

**P 0341 = 0** signifies selection of the **1/n** characteristic (no parameter setting)

**P 0341 ≠ 0** signifies selection of **Isd = f/n** characteristic (modified 1/n characteristic).

Parameterization of **Isd = f/n** characteristic setting of d-current dependent on the speed. The speed is specified relative to the rated speed in **P0458 MOT_SNom**, the d-current relative to the magnetizing current in parameter **P 0340 CON_FM_Imag**. Up to the field-weakening speed, a constant magnetizing current is injected **P 0340 (0-7)**.

| P. no. | Parameter name/ Settings | Designation in DM5 | Function |
|---|---|---|---|
| P 0340 | CON_FM_Imag | magnetization current (r.m.s) | Effective value of the rated current for magnetization |
| P 0341 | CON_FM_ImagSLim | Only valid for ASM | Field-weakening activation point (as % of P 348 MOT_SNom). This effects the switch from the 1/n to the Isd=f/n) characteristic.<br><br>For a synchronous machine this value must be set to 0. |

| P. no. | Parameter name/ Settings | Designation in DM5 | Function |
|---|---|---|---|
| P 0342 | CON_FM_SpeedTab | speed values for mag. current scaling | Speeds (as % of P 0340 CON_FM_ Imag) Used to set the field-weakening characteristic. |
| P 0343 | CON_FM_ImagTab | mag. current scaling vs. speed | d-current scaled as Imag (as % of P 0340 CON_FM_Imag). Used to set the field-weakening characteristic. |

Application example:

| | P 0348 Rated speed | P 0342 (0-7) Field-weakening speed | P 0340 (0-7) Magnetizing current in field-weakening mode |
|---|---|---|---|
| (0) | $n_{nom}$ = 1800 rpm | 100 % | 0 A |
| (1) | | 110 % | 55 A |
| (2) | | 120 % | 70 A |
| (3) | | 130 % | 90 A |
| (4) | | 140 % | 100 A |
| (5) | | 150 % | 100 A |
| (6) | | 160 % | 100 A |
| (7) | | 170 % | 100 A |

Attention: The speeds in **P 0342 CON_FM_SpeedTab** must continuously increase from index 0 -7.

## Voltage regulator parameters

The voltage regulator is overlaid on the selected characteristic. When using the voltage regulator, a portion of the available voltage is used as a control reserve. The more dynamic the running, the more control reserve is required. In this case it may be that the voltage for rated operation is not sufficient, and also that the regulator starts to oscillate.

The PI voltage regulator can be optimized by adaptation of the P gain **P 0345**, the lag time **P 0346** and the filter time constant for the motor voltage feedback **P 0344**. Parameter **P 0347** sets the voltage reference, though the threshold needs to be reduced in response to rising demands as this maintains a kind of voltage reserve for dynamic control processes.

A certain voltage reserve is necessary for stable operation. It is specified by way of parameter **P347 CON_FM_VRef** (< 100 %). The value should be set high ( <= 90 %) where there are high demands in terms of dynamics. For less dynamic response, the maximum attainable torque can be optimized by higher values (> 90 %).

Note: If the control reserve is too small, the inverter typically shuts off with an overcurrent error.

Parameter

| P. no. | Parameter name/ Settings | Designation in DM5 | Function |
|---|---|---|---|
| P 0344 | CON_FM_VConTF | voltage control filter time constant | Time constant of the voltage regulator actual value filter |
| P 0345 | CON_FM_VConKp | voltage control gain | Voltage regulator gain factor Kp |
| P 0346 | CON_FM_VConTn | voltage control integration time constant | Voltage regulator lag time Tn |
| P 0347 | CON_FM_VRef | voltage control reference (scaling of max. voltage) | Voltage regulator reference (as % of the current DC link voltage) If the value 0 % is set, the regulator is not active. |
| P 0348 | MOT_SNom | Motor rated speed | Rated speed of the motor |

Default values:

| | | |
|---|---|---|
| P 0344 | CON_M_VConTf | 10 ms |
| P 0345 | CON_FM_VConKp | 0.1 A/V |
| P 0346 | CON_FM_VCon_Tn | 100 ms |
| P 0347 | CON_FN_VRef | 90 % |

## Synchronous motor field-weakening

Synchronous motors can also be operated above their rated speed at rated voltage, by reducing their voltage consumption based on on injection of a current component.

# Field weekening for Synchronousmotor

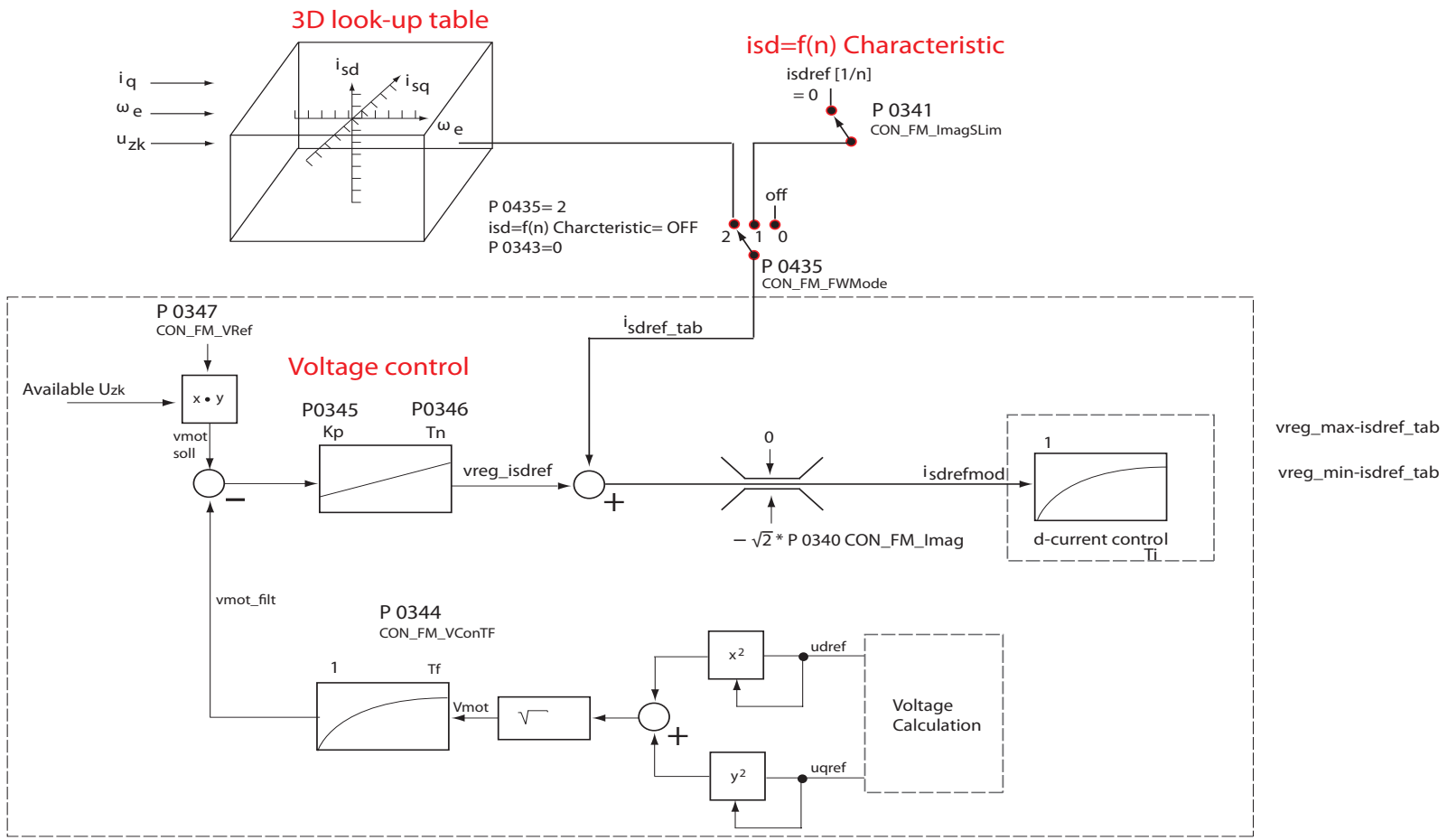



*Figure 4.25 Synchronous machine field-weakening*

The following conditions must be met.

1. To effectively reduce the voltage consumption, the ratio of stator inductance ( P 0471) x rated current (P 0457) to rotor flux (P 0462) must be sufficiently large.

$$L_{Stator} > \Phi_{Rotor} \mathrel{\hat{=}} P\,0457 * P\,0471 > Factor * P\,0462$$

$$Factor > 0{,}2$$

2. If the speed achieved by field-weakening is so high that the induced voltage exceeds the overvoltage threshold of the device (for 400 V devices approximately 800 V, for 230 V devices approximately 400 V), this will result in DESTRUCTION of the servocontroller if no additional external safety measures are applied.

Condition:

$$\text{Rotorflux} * \text{Maximal speed} \quad \text{(in rad/s)} < 700\ V$$

$$\mathrel{\hat{=}}$$

$$P\,0462 * (P\,0458 * P\,0328) * \frac{2\Pi}{60} < 700$$

Attention: When configuring projects, it must be ensured that the speed NEVER exceeds the value of $n_{max}$. In such cases the induced no-load voltage reaches the overvoltage limit.

3. In contrast to field-weakening of asynchronous motors, synchronous motors can also be operated in the "field-weakening range" with full rated torque at the nominal value of the q-current. Power beyond the rated power output can therefore be drawn from the machine in field-weakening mode, even at rated current. This must be taken into consideration when configuring the motor.

The maximum amount of the "field-weakening" d-current is defined by parameter CON_FM_Imag P340 (specification of effective value).

Note: Parameter P 0341 must be set to zero for synchronous machines.

For field-weakening of synchronous motors, various options are implemented. The method is selected via parameter P0435 FWMode, which specifies how the d-current reference is calculated.

| P. no. | Parameter name/ Settings | Designation in DM5 | Function |
|---|---|---|---|
| P 0435 | CON_FM_FWMode | Fieldweakening mode for synchrounus motors | Selection mode for field-weakening of synchronous motors |
| (0) | None | Fieldweakening is disabled | Field-weakening is off, regardless of other settings. |
| (1) | Table | Isd set by PI Controller and table parameter | Field-weakening is effected by way of a characteristic which specifies the d-current dependent on the speed isd = f(n) and is set via parameters P342 and P343. |
| (2) | Calc | Isd set by PI Controller and motor parameter | Field-weakening is effected by way of a characteristic which is set internally via the motor parameters. The d-current reference is then calculated dependent on the speed AND the required q-current: isd = f(n, isq_ref). The inaccuracies with regard to the motor parameters, the available voltage etc. can be compensated by way of the Scale parameters P436. |

Note: In mode 1 and mode 2 the voltage regulator can be overlaid. It is also possible in mode 1 to disable the characteristic and run solely with the voltage regulator.

### Selection of field-weakening method:

This is how to select a suitable method from the various options:

Select setting **P 0435 CON_FM_FWMode** = (1) Table

If no rapid speed change in the field-weakening range is required, the voltage regulator is well suited (setting 1).

Disable table **P 0341** = 0 and set entries in field parameter **P 0343** = 0

Features of this method:

- The method is relatively robust against parameter fluctuations.
- The controller can only follow rapid speed and torque changes to a limited degree.
- A non-optimized controller may cause oscillation; the controller must be optimized.

A presetting of the controller is effected when calculating the motor data via parameter **P 1530 -> 1** (see "Motor" section).

If oscillation occurs when applying this method, the voltage regulator gain setting **P 0345** must be reduced. If substantial variations between the q-current reference and actual values occur during run-up to reference speed in the field-weakening range, the drive may be at the voltage limit. In this case, a check should first be made as to whether the preset maximum value **P 0340** has already been reached and can be increased. If the maximum value has not yet been reached, the voltage regulator is not dynamic enough and the gain **P 0345** must be increased.

If no suitable compromise can be found, the voltage threshold as from which the voltage regulator intervenes must be reduced by the scaling parameter **P 0347 CON_FM_VRef**. This then also quadratically reduces the torque available when stationary however.

If the response with voltage regulator is unproblematic and no particular demands are made in terms of dynamics, the available torque can be optimized by setting **P 0347** to values up to 98 %.

Select setting **P 0435 CON_FM_FWMode = (2) Calc**

If very rapid speed or load changes occur in the field-weakening range, the setting **P 0340 CON_FM_FwMode = 2** is preferable.

Features of this method:

- Very fast adaptations, with high dynamism, are possible (open-loop control method).
- Motor parameters must be known quite precisely.
- A badly set table can result in continuous oscillation.

If continuous oscillation occurs, it should first be determined whether the drive is temporarily at the voltage limit. The preset negative d-current value is then not sufficient. In this case the scaling parameter **P 0436** can be used to evaluate the map at higher speeds (**P 0436 > 100 %**).

The voltage regulator is overlaid on the evaluation of the map if the gain **P 0345** is set greater than zero. The voltage regulator can be set in the same way as described above for setting 1.

The set combination of voltage regulator and map entails the highest commissioning commitment, but it enables the best stationary behaviour (highest torque relative to current) and the best dynamic response to be achieved.

## 4.4.3 Autocommutation

For field-oriented regulation of permanently excited synchronous machines with a purely incremental measuring system, the commutation position must be determined once when the control is started (adjustment of current rotor position to encoder zero [Encoder offset]).

This procedure is executed by the "Autocommutation" function after initial enabling of the control when the mains voltage has been switched on for the first time. It can also be forced during commissioning by changing a parameter, which causes a complete controller initialization (e.g. change of autocommutation parameters, change of control mode, etc.).

Owing to the differing requirements arising from the applications, various commutation methods are provided. The selection is made via the selector **P 0390 CON_ICOM**.

For synchronous machines with no absolute measuring system, the two methods **IENCC(1)** and **IECON(4)** are recommended. Use of the much more complex LHMESS(2) commutation method requires prior consultation with LTi DRiVES.

Selection of commutation method:

| P. no. | Parameter name/ settings | Designation in DM 5 | Function |
|---|---|---|---|
| P 0390 | CON_ICOM | Selection of commutaionfin-ding-method | Selection of the commutation method |
| | OFF(0) | Function off | No commutation method selected |
| | IENCC(1) | Current injection | IENCC (1) autocommutation with movement: An easily parameterized method in which, however the rotor moves by as much as half a revolution, or half a pole pitch unit (where p = 1). |
| | LHMESS(2) | Saturation of inductance evaluated | 2. LHMES (2) autocommutation with braked machine:<br>The machine must be blocked by a suitable brake during auto-commutation. The occur-ring torques and forces may attain the rated torque and force of the machine. |
| | IECSC(3) | not implemented | Not implemented! |
| | IECON(4) | Current injection minimized movement | IECON (4) autocommutation with minimized movement:<br>Here, too the rotor must be able to move, though appropriate parameter-setting can reduce the rotor movement to just a few degrees per mm. |
| | HALLS(5) | not implemented | HALLS (5) autocommutation: Evaluation of analog Hall sensors (from V 2.0) |

## The IENCC(1) method (movement of shaft permitted)

In the IENCC method the rotor aligns in the direction of the injected current and thus to a defined position. The relatively large movement (up to half a rotor revolution) must be taken into consideration.

This method cannot be used near end stops or limit switches! It is advisable to use the rated current $I_{nom}$. The time should be set so that the rotor is at rest during the

measurement. For control purposes, the commutation process can be recorded with the Drive-Manager Scope function.

## The IECON(4) method (movement of shaft not permitted)

The motor shaft motion can be minimized by an angle controller. The structure and parameters of the speed controller are used for the purpose. The gain can be scaled via parameter **P 0391 CON_ICOM_KpScale**. This therefore means that the speed control loop must already be set.

- Increasing the gain results in a reduction of the motion.
- An excessively high gain will result in oscillation and noise. In both methods (1) and (4) the flux-forming current "Isdref" is injected as a test signal, the course of which is shown in the diagram. The diagram illustrates the IECON(4) method.

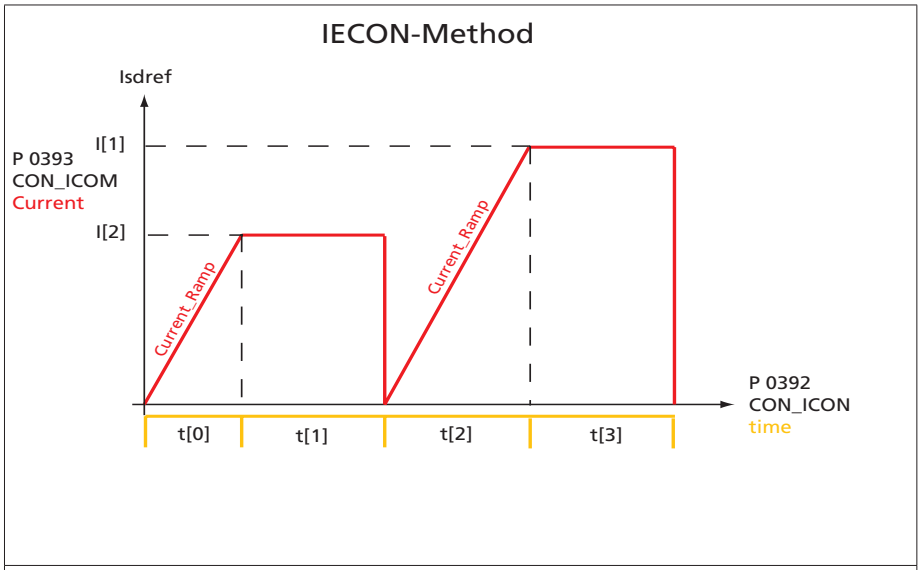



*Figure 4.26 Schematic for the IENCC(1) and IECON(4) methods*

Parameter setting:

| P. no. | Setting | Function |
|---|---|---|
| P 0391 | 0-10000 % | Scaling of dynamics |
| P 0392 | 0-10000 ms | Measuring time |
| [0] | 500 ms | Ramp time t[0] |
| [1] | 500 ms | Injected current time t[1] |
| [2] | 500 ms | Ramp time t[2] |
| [3] | 500 ms | Injected current time t[3] |
| P 0393 | Preferential value | |
| [0] | I[1] | Rated current: $I_{Nom}$ step 1 |
| [1] | I[2] | Rated current: $I_{Nom}$ step 2 |

For linear motors the values for time and current adjust automatically when calculating the data set.

Note:

- Inexperienced users should always choose the rated motor current (amplitude) as the current and a time of at least 4 seconds.
- The motor may be moved jerkily during autocommutation. The coupled mechanical system must be rated accordingly.
- If the axis is blocked, i.e. the rotor is unable to align itself freely, the methods will not work properly. As a result, the commutation angle will be incorrectly defined and the motor may perform uncontrolled movements.

## Description of the LHMES(2) method with braked machine:

In this method, saturation effects in the stator inductance are evaluated. Two test signal sequences are used for this purpose, whereby the position of the rotor axis is known after the first sequence and the direction of movement after the second.

This method is suitable for determining the rotor position with braked rotors or motors with a relatively high mass inertia.

Precondition:
The rotor must be braked so that the motor cannot move even when the rated current is applied.
The stator of the machine must be iron-core.

Parameterization of a test signal (example):

| | | |
|---|---|---|
| Frequency of test signal | f = 333 Hz | P 1506 |
| Amplitude | 1 A | P 1505 |
| Number of periods | 50 | P 1508 |
| Direct component | 3.1 A | P 1503 |

In most cases a good result is achieved with a test signal frequency of 333 Hz, an amplitude of the magnitude of one quarter of the rated current, evaluation of 50 oscillations and a direct component equivalent to the rated current (3.1A).

Attention: Parameters of the "Autocommutation" subject area may only be changed by qualified personnel. If they are set incorrectly the motor may start up in an uncontrolled manner.

Note: It is advisable to parameterize speed tracking error monitoring with the "Power stage off" error response. This monitoring feature reliably prevents the motor from racing.

# 4.5 Commissioning

## 4.5.1 Autotuning

The drive controller is able to automatically determine the mass moment of inertia reduced to the motor shaft by means of a test signal. However, this requires that the mass moment of inertia only fluctuates very little or not at all during motion.

The moment of inertia has the following effect on the control response:

- It is taken into account when calculating the speed controller gain.
- In feed forward control the moment of inertia is used to translate the acceleration into force/torque or q-current.
- In feed forward control the moment of inertia is used to translate the acceleration into force/torque or q-current.

To determine the mass inertia, the drive controller generates a pendulum movement of the connected motor complete with the mechanism and uses the ratio of acceleration torque to speed change to determine the mass inertia of the overall system.

After the control has been started, determination of the mass inertia is activated by setting the control word **P 1517 SCD_AT_JsumCon** to the value Start(2). The drive executes a short pendulum movement by accelerating several times to the parameterized speed **P 1519 SCD_AT_SConHysTorq** with the parameterized torque **P 1518 SCD_AT_SConHysSpeed**. If the torque and speed have not been parameterized (setting zero), the process uses default values determined on the basis of the rated speed and nominal torque.

The mass moment of inertia determined for the entire system is calculated after the end of the test signal and entered in parameter **P 1516 SCD_Jsum**.

Parameter:

| P. no. | Parameter name/ Settings | Designation in DM5 | Function |
|---|---|---|---|
| P-1515 | SCD_ConDesign | Speed and position control dynamic (stiffness) | Rigidity of the mechanism |
| P-1516 | SCD_Jsum | Total inertia of motor and plant | Mass moment of inertia (motor and load) |
| P-1517 | SCD_AT_JsumCon | Autotuning for Jsum estimation, control word | Automatic estimation of mass inertia |
| P-1518 | SCD_AT_SConHysSpeed | Autotuning Jsum, hysteresis speed control, speed limit | Determination of mass inertia |
| P-1519 | SCD_AT_SConHysTorq | Autotuning for Jsum, speed hysteresis control, torque limit | Determination of mass inertia |

## 4.5.2 Test signal generator (TG)

The TG is a function for optimization of the control loops over a protracted period of motion with a reference value sequence. The TG is particularly well suited to current controller optimization.

Various signal forms can be generated, with the possibility of overlaying different signal forms.

### Test signals (additive reference values)

Regardless of the control mode, (additive) references (test signals), which take effect immediately, are used for the individual control loops.
The test signal generator can overlay defined signal forms over those references. If the test signal parameter are set to zero, the "pure signal forms" are switched to the controllers (see "Structure of test signal generator").

| P. no. | Parameter name/ Settings | Designation in DM 5 | Function |
|---|---|---|---|
| P 0400 | CON_FM_AddIsdRef | additional d-current | d-current reference |
| P 0401 | CON_SCON_AddTRef | additional torque/force reference value | Torque/force reference |
| P 0402 | CON_SCON_AddSRef | additional speed reference value, direct without ramp | Speed reference without ramps |
| P 0403 | CON_IP_AddEpsRef | additional position reference value | Position reference |
| P 0404 | CON_SCON_AddSRamp | additional speed reference value, via ramp generator | Speed reference with ramp |

Note: An additive position reference **P 0403 CON_IP AddEpsRef** only takes effect in position control; the additional speed reference via ramp **P 0404 CON_SCON_AddSRamp** only takes effect in speed control mode with reference via ramp.

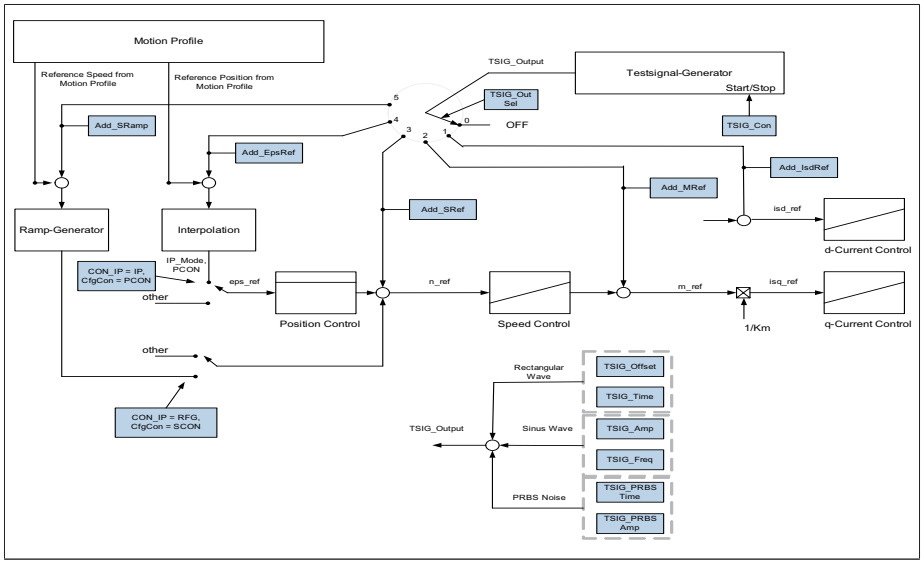



*Figure 4.27 Structure of test signal generator*

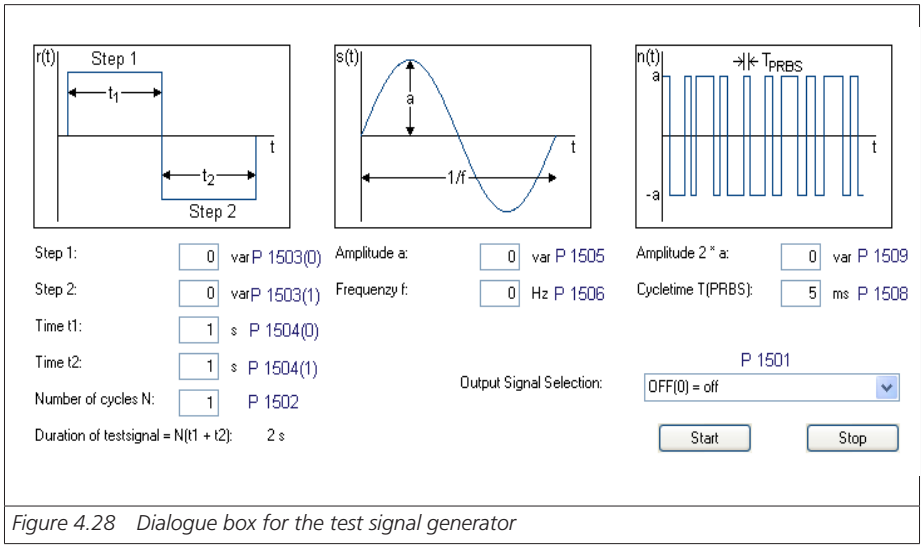



*Figure 4.28 Dialogue box for the test signal generator*

Test signal generator parameters:

| P. no. | Parameter name/ Settings | Designation in DM 5 | Function |
|---|---|---|---|
| P 0310 | CON_CCON_KP | Current control gain | Current controller gain |
| P 0311 | CON_CCON_Tn | Current integration time constant | Current controller lag time |
| P 1500 | SCD_TSGenCon | Testsignal generator control word | Control word of test signal generator |
| P 1501 | SCD_TSIG_OutSel | Testsignal generator output signal selector | Test signal generator output selector |
| P 1502 | SCD_TSIG_Cycles | Number of Testsignal Cycles | Number of cycles |
| P 1503 | SCD_TSIG_Offset | Testsignal generator Offsets | Level of square signal |
| P 1504 | SCD_TSIG_Time | Testsignal generator times for rectangular waves | Period of square signal |
| P 1505 | SCD_TSIG_Amp | Testsignal generator amplitude of sinusoidal wave | Amplitude of a sine signal |
| P 1506 | SCD_TSIG_Freq | Testsignal generator frequence of sinusoidal wave | Frequency of sine |
| P 1507 | SCD_TSIG_SetPhase | Testsignal generator initial phase for rotating current vector | Start phase of current space vector in VFCON and ICON mode |
| P 1508 | SCD_TSIG_ PRBSTime | Testsignal generator PRBS minimum toggle time | PRBS signal generator, cycle time |
| P 1509 | SCD_TSIG_ PRBSAmp | Testsignal generator PRBS signal amplitude | PRBS signal generator, amplitude |

The duration of a test signal sequence results from the parameterized times t1, t2 **P 1504 (0,1)** and the number of test cycles "Ncyc" **P 1502** for the square signal sequence:

- Square signal sequence: The signal level is set via **P 1503(0,1) SCD_TSIG_Offset** and the times via **P 1504(0,1) SCD_TSIG_Time**.
- Sine generator with presetting of amplitude **P 1505 SCD_TSIG_Amp** and frequency **P 1506 SCD_TSIG_Freq**
- A PRBS (Pseudo-Random Binary Sequence) noise signal with presetting of amplitude **P-1509 SCD_TSIG_PRBSAmp** and cycle time **P-1508 SCD_TSIG_ PRBSTime**. This enables different frequency responses to be plotted.

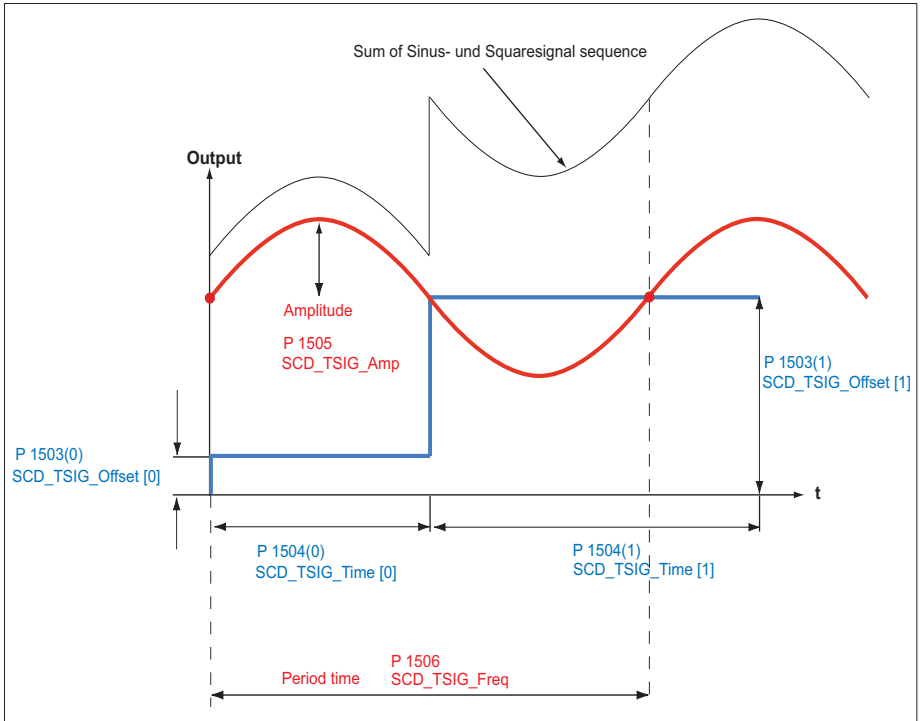



*Figure 4.29 Addition of sine and square signal*

The PRBS signal is suitable for achieving a high-bandwidth system excitation with a test signal. A binary output sequence with parameterizable amplitude **P 1509 SCD_TSIG_ RBSAmp** and a "random" alternating frequency is generated with the aid of a looped-back shift register.

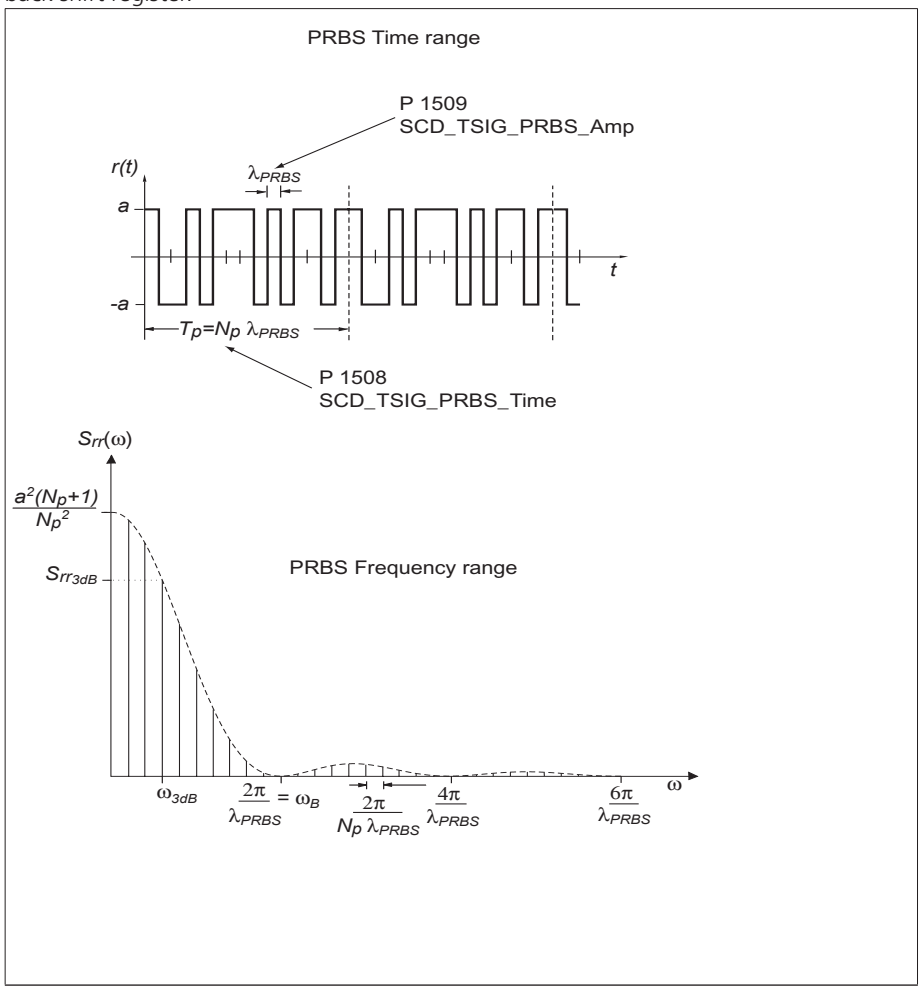



*Figure 4.30 PRBS signal in time and frequency range*

## 4.6 Motor test via VFC characteristic

In VFC mode it is possible to run a simple test indicating to the user whether a motor is connected correctly and moving in the right direction (linear drive: clockwise/anti-clockwise). If the direction has been reversed, the motor is stopped or executing uncontrollable movements, the termination plan and the motor data must be checked.

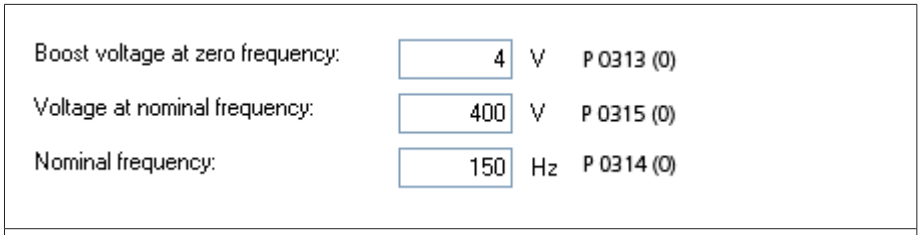



*Figure 4.31 V/f open loop control for test purposes*

As a test mode, a voltage/frequency control system is implemented in such a way that the closed-loop speed control circuit is replaced by open-loop control. So the reference in this case is also the speed reference; the actual speed is set equal to the reference. The feed frequency "fref" is calculated by way of the number of pole pairs of the motor **P 0463 MOT_PolePairs.**

$$f_{ref} = \frac{n_{ref}}{60} \times \text{P 0463\_Mot polpairs}$$

A linear characteristic with two interpolation points is implemented, with a fixed boost voltage setting **P 0313 CON_VFC_VBoost** at 0 Hertz.

As from the rated frequency **P 0314 CON_VFC_FNom** the output voltage remains constant. An asynchronous machine is thus automatically driven into field-weakening as the frequency rises.

The phase-to-phase voltages are specified under the voltages. The internal voltage reference (space vector variable) is thus:

$$\text{usdref} = \text{sqrt}(2/3) \times \text{CON\_VFC\_VBoost} + \frac{\text{CON\_VFC\_VNom}}{\text{CON\_VFC\_FNom}} \times \text{ref}$$

The reference is set by parameter **P 0402 CON_SCON_AddSRef** [rpm]

Parameter

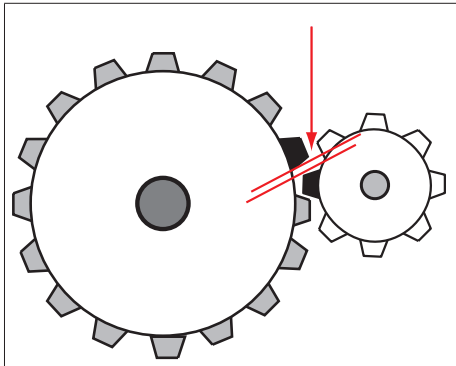
| P. no. | Parameter | Function | Description |
|---|---|---|---|
| P 0313 | CON_VFC_VBoost | boost voltage (at zero frequency) | Boost voltage at standstill |
| P 0314 | CON_VFC_FNom | nominal frequency | Rated frequency |
| P 0315 | CON_VFC_VNom | voltage at nominal frequency | Voltage at rated frequency |
| P 0402 | CON_SCON_AddSRef | Additional speed reference value via VFC characteristic | Speed reference without ramps |

## 4.6.1 Axis error compensation

The actual position value delivered by the encoder system and the real actual position value on the axis may vary for number of reasons.
These may be:

- Inaccuracy of the measuring system
- Transfer inaccuracies in mechanical elements such as the gearing, coupling, feed spindle etc.
- Thermal expansion of machine components.

To compensate for these non-linear inaccuracies, the axis error compensation function can be used.



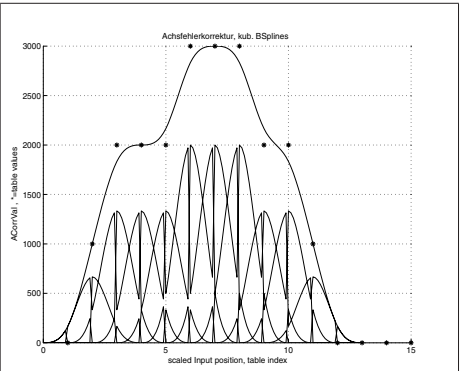



*Figure 4.32 Axis error compensation*

Example of axis error correction in case of interpolation with cubic B-splines

Parameters: (all values in user-defined path units)

| P. no. | Parameter name/ Settings | Designation in DM 5 | Function |
|---|---|---|---|
| P 0590 | ENC_ACOR_Sel | Axis Correction: Select | Encoder assignment: Setting range 0=OFF,1=encoder1, 2= encoder2 (see ENCODER section 3.6) |
| P 0591 | ENC_ACOR_PosStart | Axis Correction: Start Position | Definition of correction range: The range is defined by parameters P 0591 Start Position and P 0592 End Position. The start position is user-specified; the end position is determined from the maximum value of correction table interpolation points used P 0595, P 0596 and the interpolation point pitch P 0593. |
| P 0592 | ENC_ACOR_PosEnd | Axis Correction: End Position | |
| P 0593 | ENC_ACOR_PosDelta | Axis Correction: Delta Position | Interpolation point pitch: The positions at which the correction interpolation points are plotted are defined via parameters P 0593 Interpolation point pitch and P 0591 Start position. Between the correction interpolation points, the correction values are calculated by cubic spline interpolation. |
| P 0594 | ENC_ACOR_Val | Axis Correction: Actual Position Value | Actual position |
| P 0595 | ENC_ACOR_VnegTab | Axis Correction: Table for neg. speed | Correction table for negative direction |
| P 0596 | ENC_ACOR_VposTab | Axis Correction: Table for pos. speed | Correction table for positive direction |

For precision machining (such as spindle drives) position and directions-dependent correction values must be used in the drive controller.

For this, a correction value table is filled with values for each of the two directions. The respective correction value is produced from the current axis position and the direction of movement by means of cubic (jerk-stabilized) interpolation. The actual position value

is adapted on the basis of the corrected table. Both tables contain 250 interpolation points.

## Directional dependence of the correction

In speed-controlled mode the directional dependence is determined by way of the rated speed, whereas in positioning it is determined from the speed feed forward control value (scope variable nref_FF) by comparison with a standstill window. If there is no mechanical play, such as in the case of direct drives, both tables must be filled with the same values.

The standstill window setting is currently fixed at 1 $min^{-1}$.

- The function is only active when **P 0590 ENC_ACOR_Sel** is unequal to OFF, **P 0593 ENC_ACOR_PosDelta** is unequal to zero and homing has been carried out.
- New values only take effect following control initialization (retrigger ENPO and enable).
- Start position **P 0591 ENC_ACOR_PosStart**, resolution **P 0593 ENC_ACOR_PosDelta** and the last table index of **P 0595 ENC_ACOR_VnegTab** or **P 0596 ENC_ACOR_VposTab** unequal to zero produce the end position **P 0592 ENC_ACOR_PosEnd.**

Note: The parameters are set in the selected user unit for the position as integer values.

Note: It is advisable to use the same number of correction interpolation points for the positive and negative directions. The first and last correction values in the table must be zero in order to avoid instability (step changes) in the actual position value.

Note: Differing correction values for the positive and negative directions at the same interpolation point will lead to instability in the associated actual position value when the direction is reversed, and so possibly to a step response adjustment to the reference position.

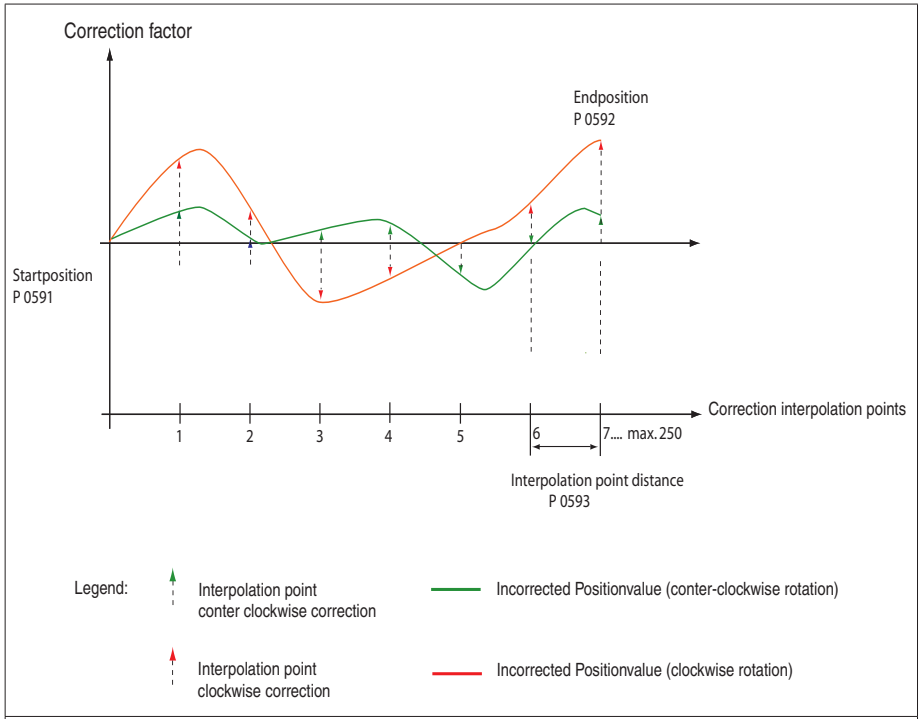



*Figure 4.33 Correction value formation from the defined correction interpolation points*

# 5. Motion profile

At the start of drive parameterization the reference interface between Motion Profile and loop control is configured. In the dialogue box the basic settings necessary for initial turnover of the drive can be set (see below).

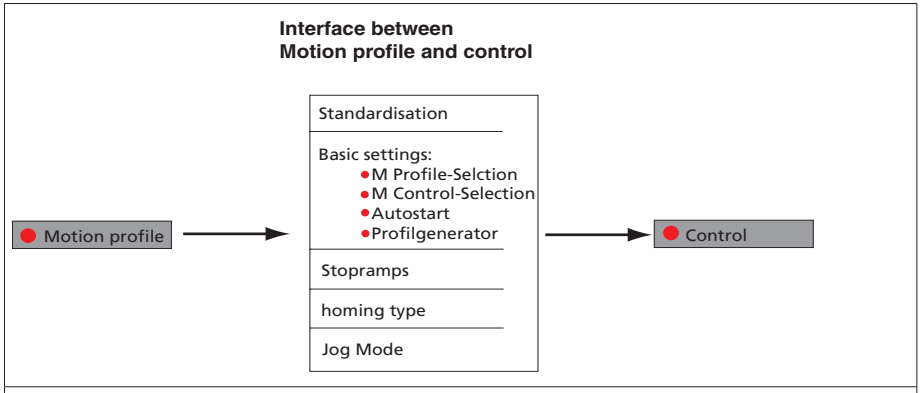



*Bild 5.10 Reference interface*

Motion Profile screen

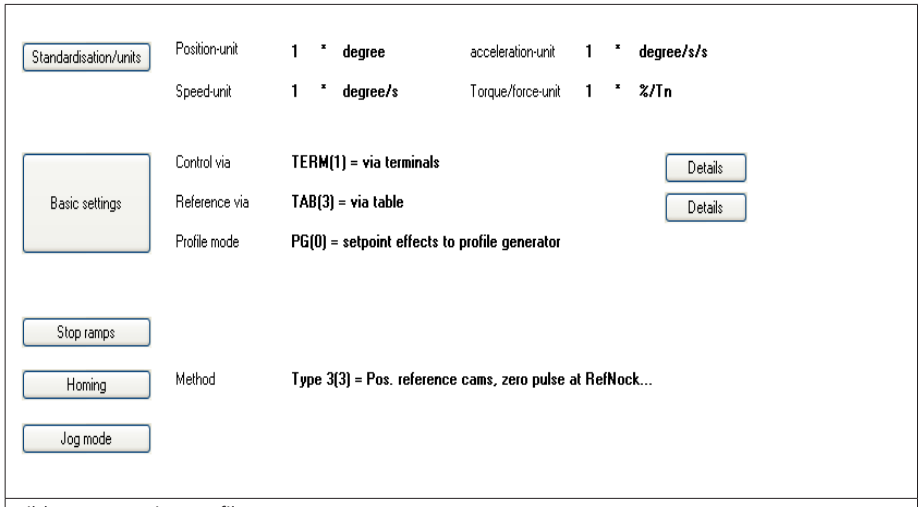



*Bild 5.11 Motion Profile screen*

## 5.1 Scaling

By way of Motion Control, reference values must be preset in user-defined travel units. These values must be converted into internal units. This section describes how the various factors influence the system, how they are calculated and what variables are required for the purpose. A wizard is provided for scaling in the standard/CiA DS402 and SERCOS profiles. To start it, click the "Standardisation/units" button. Scaling via USER is only possible by way of the Parameter Editor.

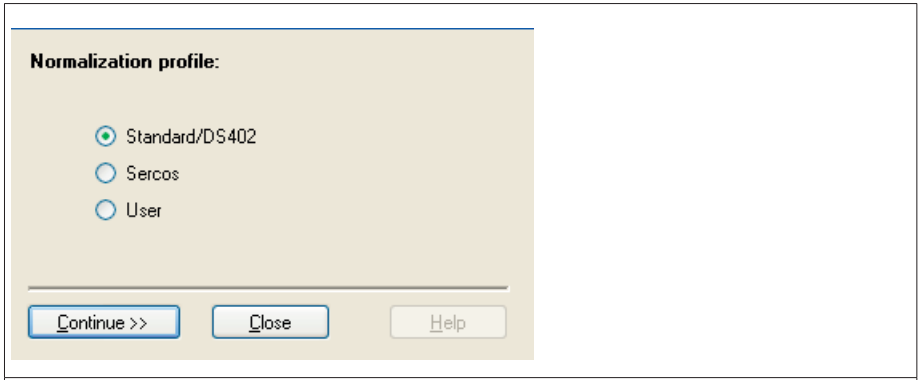



*Figure 5.1 Selection of scaling mode*

| P.no. | Parameter name/Setting | Designation in DM 5 | Function |
|---|---|---|---|
| P 0283 | MPRO_FG_Type | Factor group Type selection | Scaling source |
| (0) | STD_DS402 | Standard acc. To CANopen DSP402 | Scaling is based on the parameters specified in the CIA 402 profile. Used in open-loop control via terminal or PLC |
| (1) | SERCOS | Units acc. To SERCOS | Scaling is based on the parameters specified in the SERCOS profile |
| (2) | User specific | User defined units | Scaling is based on parameters P-270 to P275 |

## 5.1.1 Standard/CiA 402 profile

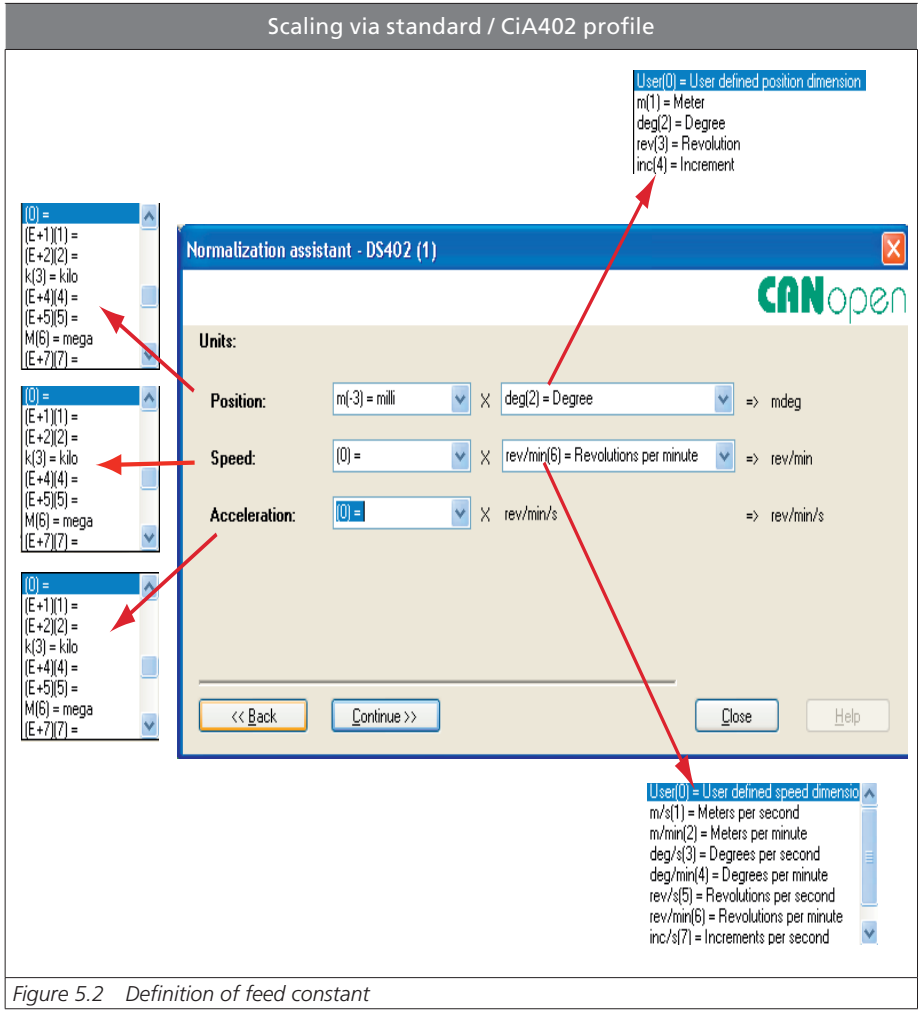



*Figure 5.2 Definition of feed constant*

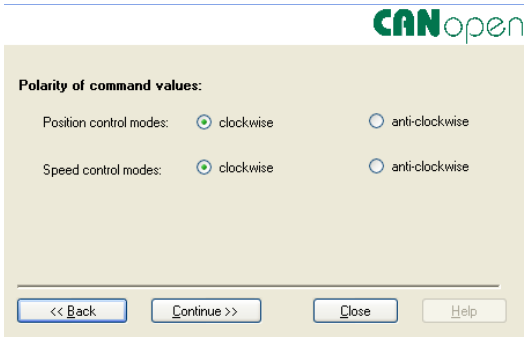
| Scaling via standard / CiA402 profile |
| --- |
| In this dialogue box the units for the position, speed and acceleration are defined. The **>Continue** button navigates the user through the subsequent dialogue boxes.<br><br>In the catalogue windows of these three variables initially the exponent is set. The desired units for position and speed must also be selected. |
|  |
| Definition of direction: Referred to the motor, the positive direction is clockwise as seen when looking at the motor shaft (A-side bearing plate).<br><br>Input of changes should not be aborted prematurely. Always finish the action in the regulation manner and restart input from the first screen. |

*Figure 5.2 Definition of feed constant*

| Scaling via standard / CiA402 profile |
| --- |

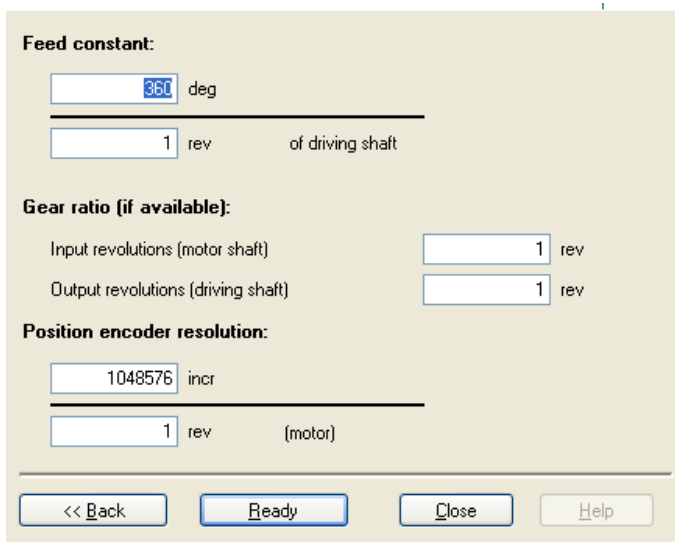



*Figure 5.2 Definition of feed constant*

**Scaling via standard / CiA402 profile**

**"Feed constant"** defines the ratio of the feed rate to the motor revolution.

$$\text{feed constant} = \frac{\text{Feed forward}}{\text{Motor revolution gear output side}}$$

**Gear ratio"** defines the ratio of a motor revolution upstream of the gearing to the number of revolutions on the gear output side.

$$\text{gear ratio} = \frac{\text{Motor revolution}}{\text{Revolution at gear output side}}$$

**"Position encoder resolution"** defines the encoder resolution in increments per motor revolution.

$$\text{Position encoder resolution} = \frac{\text{Encoder Increments}}{\text{Motor revolution}}$$

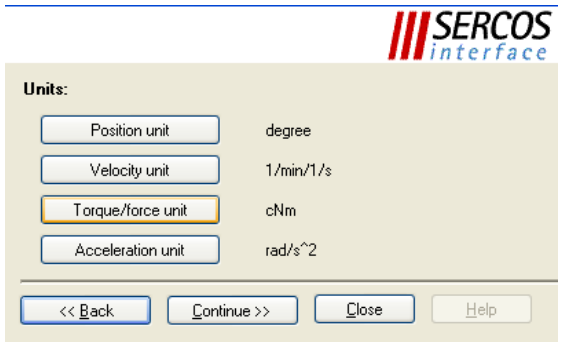
*Figure 5.2 Definition of feed constant*

## 5.1.2 SERCOS profile

When using the SERCOS profile, the term "weighting" is used in defining the units. The weighting describes the physical unit and number of decimal places with which the numerical values of the parameters exchanged between the master control system and the drives are to be interpreted. The method of weighting is defined by the parameters for position, speed, torque and acceleration weighting.

Note: If no weighting is selected, the weighting factor and weighting exponent are irrelevant.

**Weighting via the SERCOS profile**




This is the start screen of the SERCOS scaling wizard, in which the settings for position, speed, torque and acceleration can be made. From this screen the user is navigation through the scaling parameters.

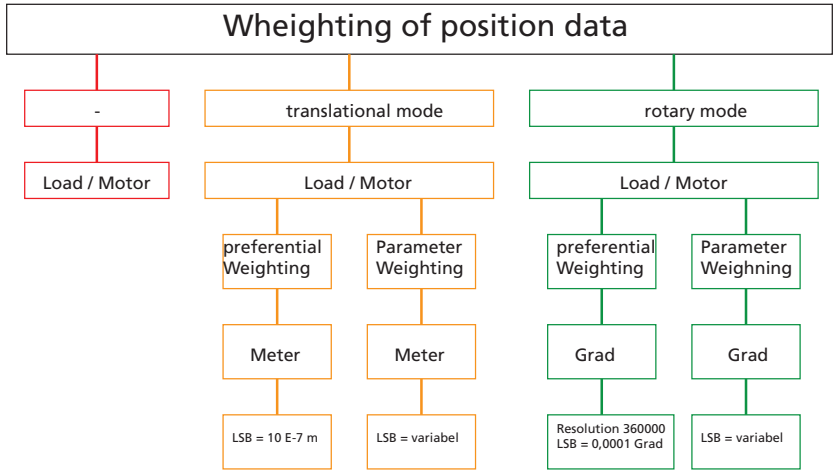
So as not to have to display all individual screens, the following schematic views are presented:

- Schematic 1 : Weighting method for position data
- Schematic 2 : Weighting method for speed data
- Schematic 3 : Weighting method for force/torque
- Schematic 4 : Weighting method for acceleration

*Figure 5.3 Weighting wizard for SERCOS*

## Weighting of position data

Schematic 1: Position data




### Position resolution in translational mode:

LSB = Unit * Exponent

Preferential translational weighting:

| Weighting method | Unit | Weighting factor | Weighting exponent | Preferential weighting |
|---|---|---|---|---|
| linear | m | 1 | -7 | 0.1 µm |

*Figure 5.4 Weighting of position data*

Schematic 1: Position data

### Position resolution in rotary mode:

$$LSB = Unit * \frac{1\ Revolution}{Position\ resolution\ in\ rotary\ mode}$$

$$Example: \frac{360\ degree}{3\ 600\ 000}$$

Preferential rotary weighting:

| Weighting method | Unit | Rotary position resolution | Weighting exponent | Preferential weighting |
|---|---|---|---|---|
| rotativ | degrees | 3 600 000 | -7 | 0.0001 degrees |

### Modulo weighting

If Modulo (indexing table application) is selected, the number range of the position data (Modulo value) must be entered. If the travel exceeds the modulo range, modulo calculation is carried out.

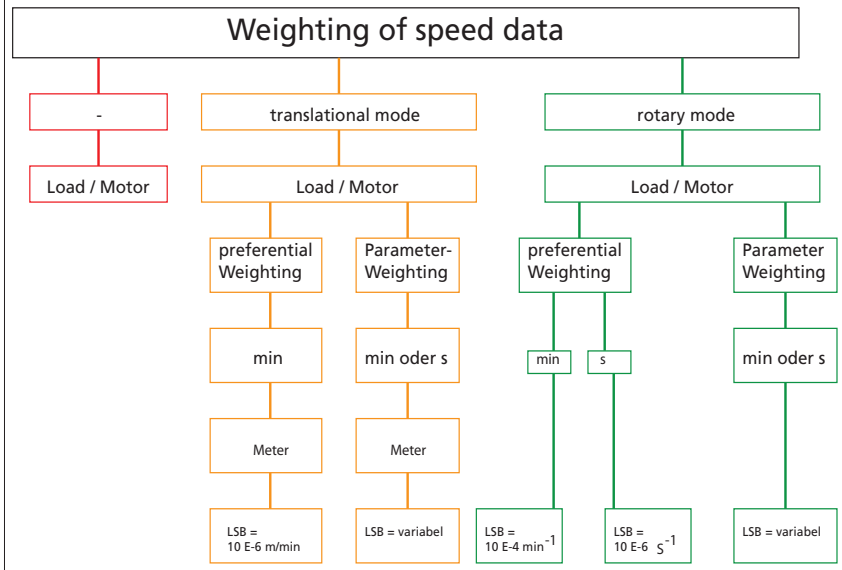
### Position polarity:

The polarity of the position data (preceding sign) can be inverted according to the application. A positive position reference indicates clockwise rotation (looking at the motor shaft).

*Figure 5.4 Weighting of position data*

## Weighting of speed data

Schematic 2: Speed data




If no weighting is selected, the weighting factor and weighting exponent are irrelevant.

*Figure 5.5 Weighting of speed data*

Schematic 2: Speed data

Position resolution in translational mode:

$$LSB = \text{Unit} * \text{Exponent} * \frac{\text{Distance unit}}{\text{Time unit}}$$

Preferential translational weighting:

| Weighting method | Unit | Weighting factor | Weighting-exponent | Preferential weighting |
|---|---|---|---|---|
| linear | m/min | 1 | -6 | 0.001 mm/min |

Preferential rotary weighting:

| Weighting method | Unit | Weighting factor | Wighting-exponent | Preferential weighting |
|---|---|---|---|---|
| rotativ | 1/min | 1 | -4 | 0.001 1/min |
| rotativ | 1/s | 1 | -6 | 0.000001 1/s |

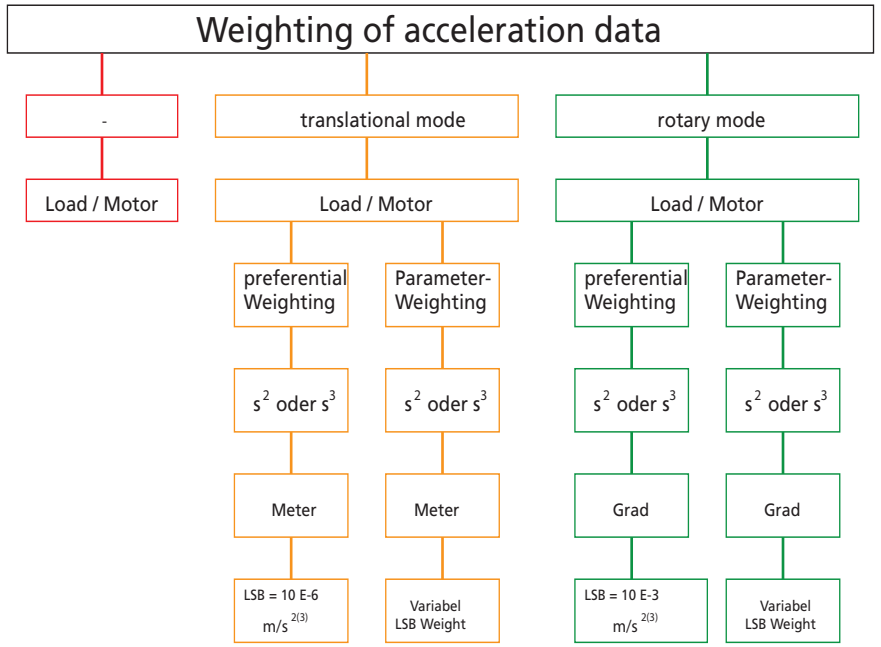
*Figure 5.5 Weighting of speed data*

Speed polarity:

The polarity of the speed data (preceding sign) can be inverted according to the application. A positive speed reference difference indicates clockwise rotation (looking at the motor shaft).

## Weighting of acceleration data

Schematic 3: Acceleration data




All acceleration data (reference, actual and limit values) are subject to the preset weighting. If no weighting is selected, the weighting factor and weighting exponent are irrelevant.

### Acceleration in translational and rotary mode:

$$\text{LSB} = \text{Unit} * \text{Exponent} * \frac{\text{Distance unit}}{\text{Time unit}}$$

*Figure 5.6 Weighting method for acceleration data*

Schematic 3: Acceleration data

### Preferential translational weighting

| Weighting method | Unit | Weighting factor | Weighting exponent | Preferential weighting |
|---|---|---|---|---|
| translatorisch | m/s² | 1 | -6 | 0.001 mm/s² |

### Preferential rotary weighting

| Weighting method | Unit | Weighting factor | Weighting exponent | Preferential weighting |
|---|---|---|---|---|
| Rotatorisch | rad/s² | 1 | -3 | 0.001 rad/s² |

*Figure 5.6 Weighting method for acceleration data*

## Weighting of torque and force data

Schematic 4: Torque/force data

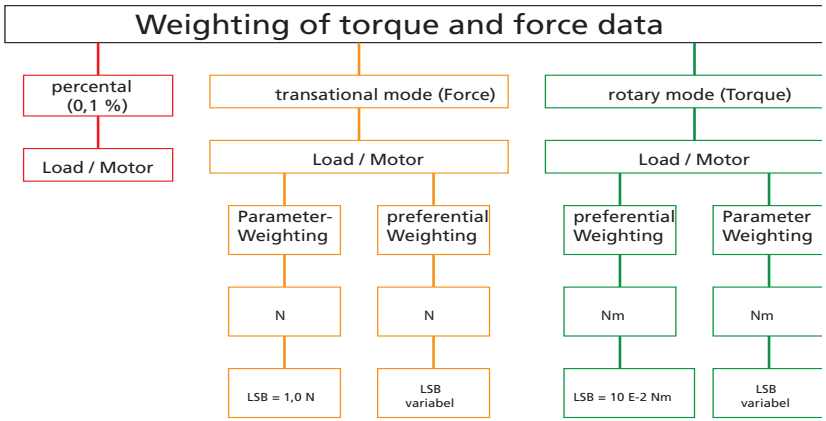



*Figure 5.7 Weighting method for torque and force data*

Schematic 4: Torque/force data

In percentage weighting the permanently permissible standstill torque of the motor is used as the reference value. All torque/force data is given in % with one decimal place.

LSB = Unit * Exponent

### Preferential translational weighting of force data

| Weighting method | Unit | Weighting-factor | Wighting-exponent | Preferential weighting |
|---|---|---|---|---|
| translatorisch | N | 1 | -0 | 1 N |

### Preferential rotary weighting of force data

| Weighting method | Unit | Weighting-factor | Wighting-exponent | Preferential weighting |
|---|---|---|---|---|
| rotatorisch | Nm | 1 | -2 | 0,01 Nm |

*Figure 5.7 Weighting method for torque and force data*

Torque polarity

The polarity is switched outside of a controlled system (at the input and output). A positive torque reference difference and non-inverted polarity means the direction of rotation is clockwise, looking at the motor shaft.

## 5.1.3 "USER" scaling without scaling wizard

No wizard is available for USER scaling, and it should only be used when scaling using the wizard is not possible. The following schematic is provided an an aid to parameter setting. Calculation of the factors **P 0271 / P 0272** for position, **P 0274** for speed and **P 0275** for acceleration is dependent on the selected "User Unit"1 and the feed constant or gear ratio.

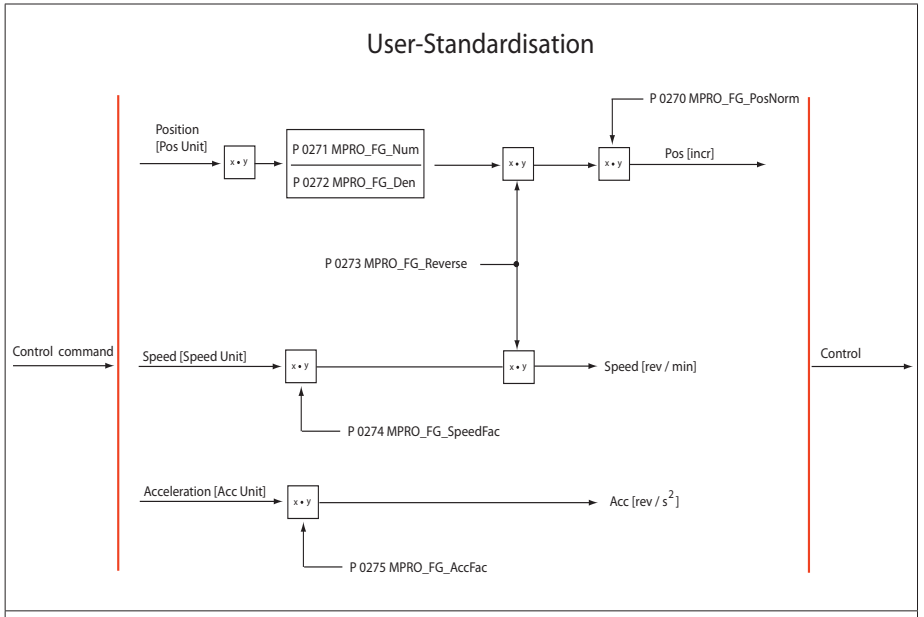



*Figure 5.8 Schematic of user scaling*

## 5.1.4 Scaling examples for "USER" scaling:

### Rotary motor scaling:

Presetting: 1 motor revolution corresponds to 360° or 1048576 increments

- Velocity in [rpm]
- Acceleration in [rpm/s]
- Positioning in [°degrees]

**Example:**

| | | |
|---|---|---|
| **Given:** | Pos Unit: | **P 0284** = µm |
| | Speed Unit: | **P 0287** = m/s |
| | Acc Unit: | **P 0290** = m/s2 |

| | | |
|---|---|---|
| **Feed constant:** | 1 mm | = 10 rev |
| **Gearing:** | 1 drive revolution | = 3 motor revs |

Parameter setting:

**Pos Unit:**

1 µm = 1/1000 mm = 10/1000 rev (output) = 30/1000 rev (motor)

**P 0271** = 30 or **P 0271** = 3

**P 0272** = 1000 or **P 0272** = 100

**Speed Unit:**

1 m/s = 1000 mm/s = 10 000 rev/s (output) =
30 000 rev/s (motor)*60 (min) = 1 800 000 rev/min

**P 0274** = 1 800 000

**Acc Unit:**

1 m/s² = 1000 mm/s = 10 000 rev/s (output) =
30 000 rev/s² (Motor)*60 (min) = 1 800 000 rev/min

**P 0275** = 1 800 000

| P. no. | Parameter name/ Settings | Function | Default setting for rotary motor: | Internal unit |
|---|---|---|---|---|
| P 0270 | MPRO_FG_PosNom | Increments per revolution | 1048576 [incr/rev] | |
| P 0271 | MPRO_FG_Nom | Numerator | 1[rev] | Pos/1 |
| P 0272 | MPRO_FG_Den | Denominator | 360° [POS] | Position per revolution |
| P 0273 | MPRO_FG_Reverse | Reverse direction | False = clockwise | |
| P 0274 | MPRO_FG_SpeedFac | Velocity factor | 1[rpm] | rpm |
| P 0275 | MPRO_FG_AccFac | Acceleration factor | 1/60 = 0.01667 [rpm/s] | rps² |

## Linear motor scaling:

Example: Scaling of the linear motor:

Given: Travel in [µm]

Speed in [mm/sec]

Acceleration in [mm/s²]
One revolution corresponds to 32mm pitch

See **P 0274, P 0275**

| P. no. | Parameter name/ Settings | Description | Default setting for linear motor: |
|---|---|---|---|
| P 0270 | MPRO_FG_PosNorm | Increments/ revolution | 1048576 |
| P 0271 | MPRO_FG_Num | Numerator | 1 |
| P 0272 | MPRO_FG_Den | Denominator | 32000 µm |
| P 0273 | MPRO_FG_Reverse | Direction of rotation | False (clockwise) |
| P 0274 | MPRO_FG_SpeedFac | Velocity factor | **1.875 rps corresponds to 1mm/s,**<br>1/32 mm = 0.03125 rps²<br>0.03125 rps²*60 s = 1.875 rps |
| P 0275 | MPRO_FG_AccFac | Acceleration factor | 1/32 mm **= 0.03125 rps² corresponds to 1 mm/s²** |

## 5.2 Basic settings

From the "Motion Profile" screen, clicking on "Basic settings" navigates to the lower screen. In it, settings are made for the required motion profile such as control location, reference source, start condition, profiles and a possible directional limitation.

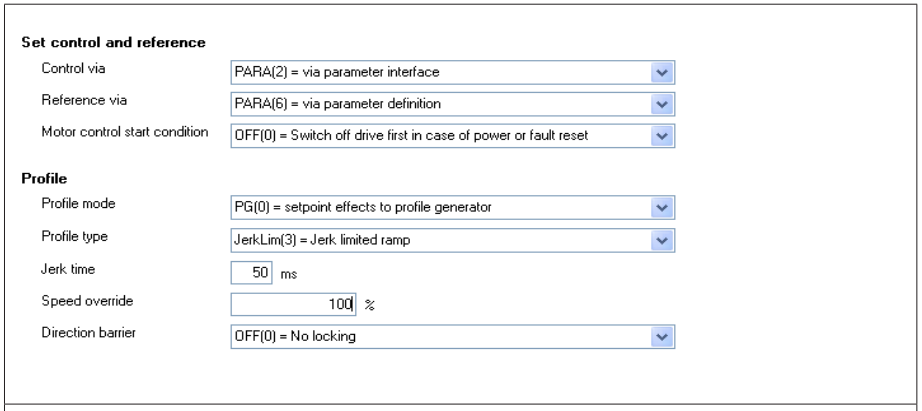



*Figure 5.9 Basic settings selection screen*

| P. no. | Parameter name/ Settings | Designation in DM 5 | Function |
|---|---|---|---|
| P 0159 | MPRO_CTRL_SEL | Motion control selection | Selection of control location |
| (0) | OFF(0) | No control selector defined | No control location selected |
| (1) | TERM(1) | via terminals | Control via terminal |
| (2) | PARA(2) | via parameter interface | via parameter |
| (3) | (3) | not defined | not defined |
| (4) | PLC(4) | via IEC 61131 program | IEC 1131 |
| (5) | CiA 402(5) | via CiA 402 motion profile (CANopen/EtherCAT) | CiA 402 |
| (6) | SERCOS(6) | via SERCOS motion profile | SERCOS |
| (7) | PROFIBUS(7) | via PROFIBUS DPV motion profile | PROFIBUS |

| P. no. | Parameter name/ Settings | Designation in DM 5 | Function |
|---|---|---|---|
| P 0144 | MPRO_DRVCOM_ Auto_start | DriveCom: Auto start of system | Autostart function |
| (0) | Off(0) | Switch off drive first in case of power of fault reset | Normal operation: The drive is stopped by cancelling the start condition or in the event of an error. |
| (1) | ON(1) | Start/Restart drive automaticly in case of power or fault | The drive automatically starts immediately on completion of initialization, provided the mains voltage is connected. |
| P 0165 | MPRO_REF_SEL | Motion profile selection | Selection of reference source |
| (0) | OFF(0) | No setpoint | No reference selected |
| (1) | ANA0(1) | via analog channel ISA0 | Analog input ISA0 |
| (2) | ANA1(2) | via analog channel ISA1 | Analog input ISA1 |
| (3) | TAB(3) | via table | Table values |
| (4) | PLC4) | Basic Library PLC open | as from V 2.0 |
| (5) | PLC(5) | via IEC 61131 program | as from V 2.0 |
| (6) | PARA(6) | via parameter definition | The reference is preset by parameter |
| (7) | CiA 402(7) | via CiA CiA 402 motion profile | CiA 402 |
| (8) | SERCOS(8) | via SERCOS motion profile | SERCOS |
| (9) | PROFIBUS(9) | via PROFIBUS DPV motion profile | PROFIBUS |
| P 0301 | Con_Ref_Mode | Select Reference Mode | Selection of interpolation type |
| (0) | PG(0) | setpoint effects to profile generator | PG(0): The internal reference is generated by the Profile Generator. In it, all ramp functions, such as acceleration and braking ramps, jerk, smoothing are implemented. The internal generation is always executed at a sampling time of 1 ms |

| P. no. | Parameter name/ Settings | Designation in DM 5 | Function |
|---|---|---|---|
| (1) | IP(1) | setpoint effects directly to control loop (without ramp) | IP(1): The reference input of the higher-level PLC is routed directly to the Fine Interpolator. Adaptation of the sampling time between the PLC and the drive controller is essential. The default setting is 125 µs. |
| P 0306 | CON_IpRefTS | Sampling time for interpolation default 250 µs | Adaptation of sampling time between ext PLC and drive controller |
| | 0,25 ms - 1000 ms | | |
| P 0370 | CON_IP | Interpolation type control | Selection of interpolation method |
| (0) | NoIp(0) | No interpolation | The interpolation methods are described in section 1.2. |
| (1) | Lin(1) | Linear interpolation | Linear interpolation |
| (2) | SplineExtFF(2) | Interpolation with external feed forward | Interpolation with external feed forward control value |
| (3) | SplineII(3) | Cubic spline interpolation | Cubic spline interpolation |
| (4) | NonIPSpline(4) | Cubic spline approximation | Cubic spline approximation |

Note: The possible settings must be checked for plausibility. The standard profile of the servocontroller is the Motion Profile CiA 402, effective for the control locations and reference sources over the CAN, EtherCAT and PROFI-BUS field buses.

### 5.2.1 Control location, control source/Set control and Reference

- P 0159: Selection of control location
- P 0165: Selection of reference source
- P 0144: Selection of controller start condition (Autostart)

### 5.2.2 Profile

- P 0301: Selection of reference processing via Profile Generator or interpolated position mode (see following section)
- P 2243: Setting of different smoothing curves (only in PG mode)
- P 0166: Setting of smoothing time (only in PG mode)
- P 0167: Setting of speed override dependent on the maximum preset reference value (only in PG mode)
- P 0335: Direction block

### 5.2.3 Profile generator/Interpolated position mode

The Profile Generator has 3 different operating modes:

- Absolute positioning
  - The specified target position is approached
- Relative positioning
  - New position = old position + relative position
- Speed mode
  - The specified speed is implemented, regardless of the position

The Profile Generator calculates the motion profile in two stages:

1. Speed profile generator:
   Calculation of the speed profile taking into account $a_{Max}$ and $v_{Max}$, followed by integration of the speed to get the travel profile.
2. Mean value filter:
   In order to limit the jerk time, a mean value filter is used to smooth the travel profile of the speed profile generator. The jerk time is proportionate to the filtering depth of the mean value filter. The longer the jerk time, the lower the resulting jerk. A jerk time of 0 means that the max. permissible acceleration can be directly used for starting or braking (the mean value filter is inactive).

## Speed control via the Profile Generator (PG mode)

To use the Profile Generator in speed control mode, the two parameters P 0301 = PG(0) and P 0300 = SCON(2) must be set.

When the reference source has been selected the reference is scaled to the matching user unit. The reference is transferred to the Profile Generator (Motion Profile) in increments and passes via the Fine Interpolator (Basic settings) to the speed controller (see figure 5.12).

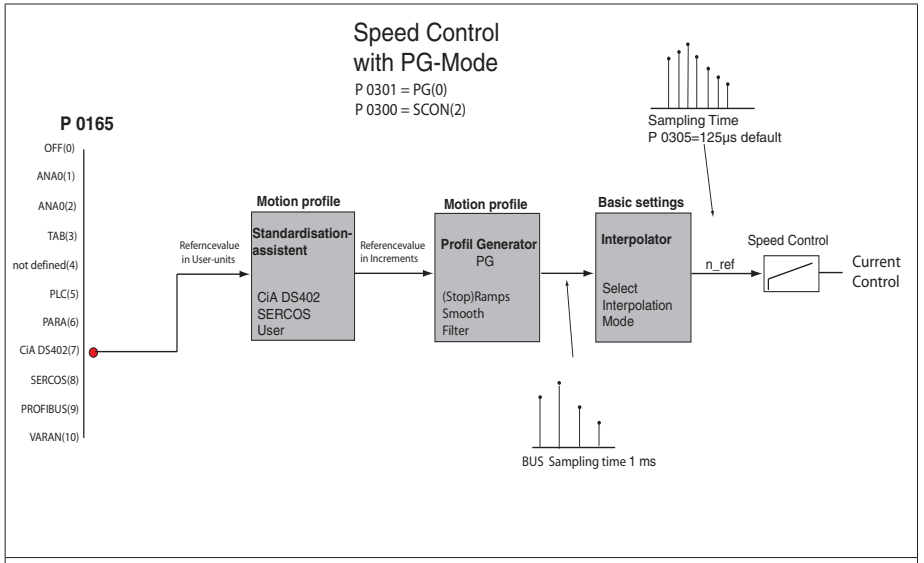



*Figure 5.10 Configuration of speed control in PG mode*

## 5.2.4 Speed control via IP mode

In speed control via IP mode (Interpolated Position mode), the reference values from the reference source are scaled, always interpolated in linear mode, and switched to the control loops. No feed forward control values are generated!

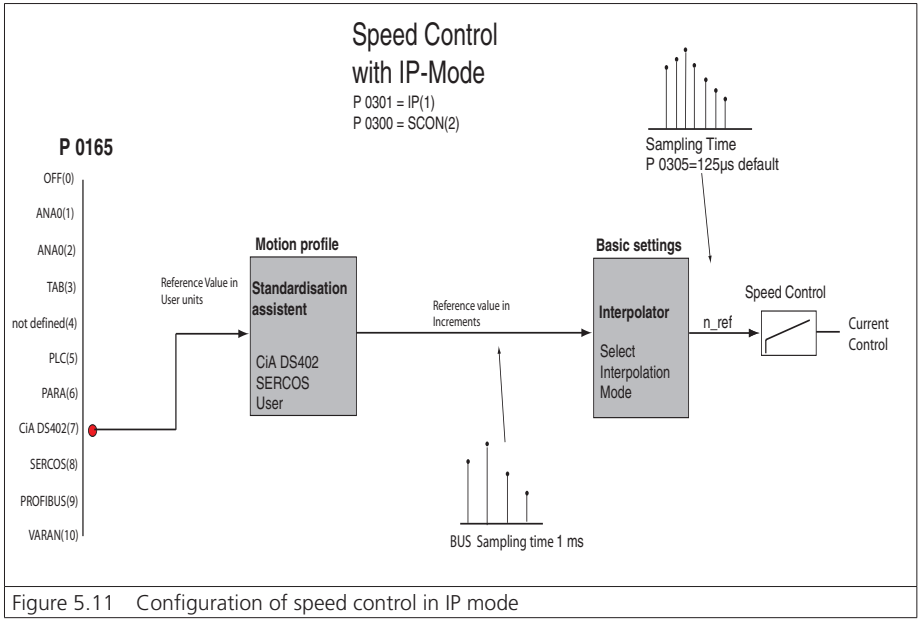



Figure 5.11 Configuration of speed control in IP mode

## 5.2.5 Position control via Profile Generator (PG mode)

In configuration of position control in PG mode, a PLC transfers complete motion commands to the internal Profile Generator. The setting is made in the Motion Profile subject area under "Basic Settings". A motion command consists of:

- Ref_Position: target position
- Ref_Speed: Maximum travel speed
- Ref_Acceleration: Maximum acceleration
- Ref_Deceleration: Maximum deceleration

With the additional information on jerk **P 0166 MPRO_REF_JTIME** and an override factor **P 0167 MPRO_REF_OVR** for the travel speed, the Profile Generator generates a time-optimized trajectory for the position reference, taking into account all limitations, in order to reach the target position.

The position reference values are then fine-interpolated in the Interpolator, with the interpolation method selected via parameter **P 0370 CON_IP**.

From the position references feed forward control values are generated for speed and acceleration. These are scanned at the sampling time of the position controller (normally 125 µs) and switched to the control loops.

Further information on how to generate motion commands using the field buses or internal options can be found in the field bus documentation.

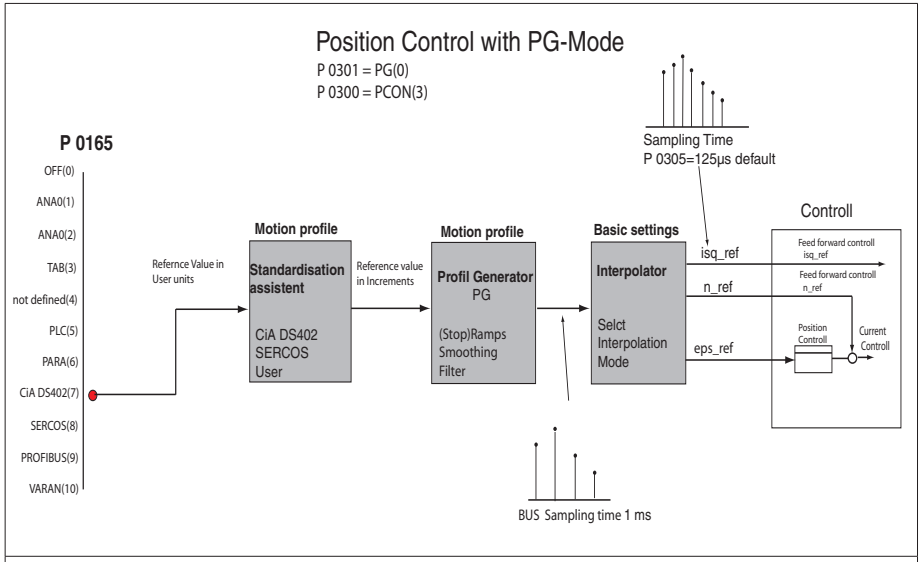



*Figure 5.12 Configuration of position control in PG mode*

## 5.2.6 Configuration of position control via IP mode

In position control configuration in IP mode, position references are set at a sampling time specified by the higher-level control. The drive controller sampling time can be matched to the sampling time of the PLC using parameter **P 0306 CON_IpRefTS**.

The position references are then transferred to the Fine Interpolator. The interpolation method to be used is set via parameter **P 0370 CON_IP**. The resulting feed forward control values for speed and acceleration are switched to the control loops.

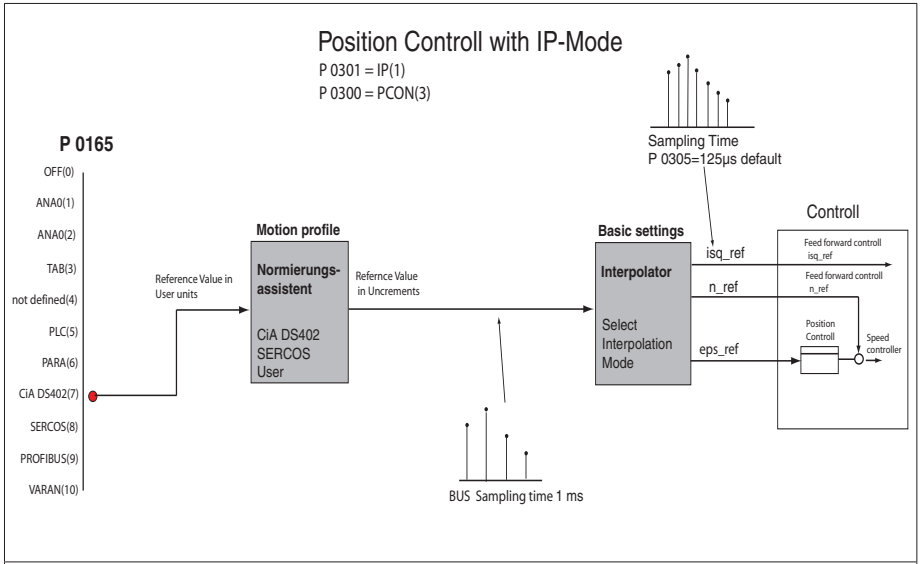



Figure 5.13 Configuration of position control in IP mode

## 5.2.7 "Smoothing" and "Velocity offset"

| P.no. | Parameter name/ Settings | Designation in DM 5 | Function |
|---|---|---|---|
| P-0166 | MPRO_REF_JTIME | Motion profile jerk time | Setting of smoothing time (jerk limitation) |
| P-0167 | MPRO_REF_OVR | Motion profile speed override factor | The reference is weighted in percent dependent on the maximum specified reference value |

The jerk limitation increases the acceleration and deceleration time by the smoothing **P 0166**. The smoothing settings field appears on the screen only when JerkLin(3) = Jerk limited ramp is set in parameter **P 2243** "Profile type" (see figures 5.16, 5.17). With Speed override **P 0167** the maximum preset speed reference can be scaled in percent.

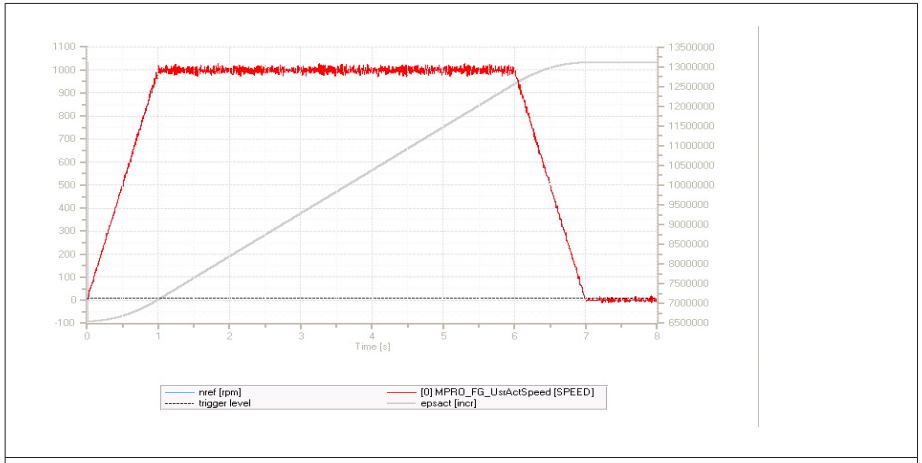



*Figure 5.14 Without smoothing: Red = actual speed value; Grey = actual position*

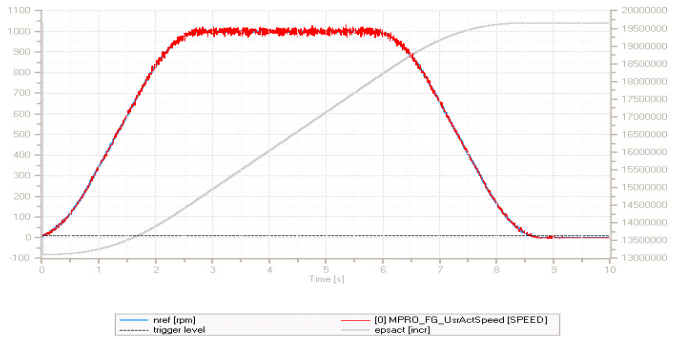



*Figure 5.15 With smoothing of 2000 ms; Red = actual speed value; Grey = actual position value*

## 5.3 Stop ramps

Each reference source has its own acceleration and braking ramps. In addition to this there are the special deceleration ramps to the CiA 402 standard listed below. The ramp functions are only effective in certain system states. The required settings can be selected from the screen. Clicking the "Error/fault reactions" button directly accesses the dialogue box for the error responses.

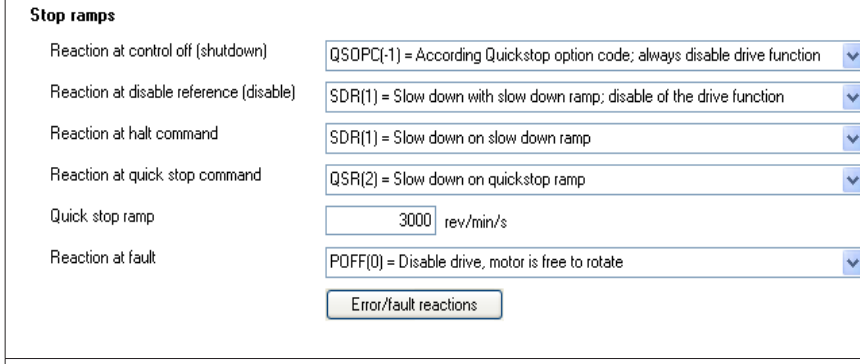

Stop ramps
Reaction at control off (shutdown)
QSOPC(-1) = According Quickstop option code; always disable drive function
Reaction at disable reference (disable)
SDR(1) = Slow down with slow down ramp; disable of the drive function
Reaction at halt command
SDR(1) = Slow down on slow down ramp
Reaction at quick stop command
QSR(2) = Slow down on quickstop ramp
Quick stop ramp
3000
rev/min/s
Reaction at fault
POFF(0) = Disable drive, motor is free to rotate
Error/fault reactions

*Figure 5.16 Stop ramps screen*

The following ramp options are available:

| P.no. | System state | Stop ramps | Preferred setting |
|---|---|---|---|
| P 2218 | Quick stop | MP_QuickStopOC | (2) |
| P 2219 | Control off | MP_ShutdownOC | (-1) |
| P 2220 | Transition from "Operation Enable" to "Switch on" | MC_DisabledOpOC | (1) |
| P 2221 | Stop feed | HaltOC | (1) |
| P 2222 | Error | MP_FaultReactionOC | |
| P 2242 | Braking ramp for quick stop | MPRO_402_QuickStopDec | |

### Response to "Quickstop Option Code"

The quick-stop brakes an ongoing movement. The drive controller is in the "Quick-stop" system state. During braking, and depending on the response, acceleration is again possible in the old "Control active" state.

| P 2218 | Designation in DM 5 | Function |
|---|---|---|
| POFF(0) | 0(0) = Disable power stage/drive function | Disable power stages; the drive coasts to a stop |
| SDR(1) | 1(1) = Slow down on slow down ramp | The drive brakes with the programmed deceleration ramp, then the power stage is disabled |
| QSR(2) | 2(2) = Slow down on slow quick-stop ramp | Braking with quick-stop ramp, then the power stage is disabled |
| CLIM(3) | 3(3) = Slow down on current limit | Braking with max. dynamics at current limit. The speed reference value is set equal to 0, then the power stage is disabled. |
| Reserve(4) | Reserve | |
| SDR_QS(5) | 5(5) = Slow down on slow quick-stop ramp and stay in quickstop | Braking with programmed deceleration ramp. The drive remains in the quick stop state, current is applied to the axis at zero speed. [1] |
| QSR_QS(6) | 6(6) = Slow down on slow quick-stop ramp and stay in quickstop | Braking with quick-stop ramp.<br>The drive remains in the quick-stop state, current is applied to the axis at speed 0. [1] |
| CLIM_QS(7) | 7(7) = Slow down on current limit and stay in quickstop | Braking with max. dynamics at the current limit,<br>the speed reference is set equal to 0.<br>The drive remains in the quick-stop state, current is applied to the axis at speed 0. [1] |
| Reserve(8) | Reserve | |

[1] *Transition to the "Ready" state is only possible by resetting the quick-stop request. In the "Quick-stop" state cancelling the "Start closed-loop control/drive" signal has no effect as long as the quick-stop request is not reset as well.*

## Response to shutdown option code / "Control off"

The state transition "Control off" is passed through when the power stage is switched off. The control is switched off by way of various control channels (terminals, bus, PLC).

| P2219 | Designation in DM 5 | Function |
|---|---|---|
| QSOPC(-1) | According Quickstop option code | In response to a shutdown command the stop variant selected in the quick-stop option code is executed |
| POFF(0) | Disable power stage/drive function | Disable power stages; the drive coasts to a stop |
| SDR(1) | Slow down with slow down ramp; disable of the drive function | The drive brakes with the programmed deceleration ramp, then the power stage is disabled |

## Response to "Disable Option Code"

The "disable operation option code" parameter determines which action is to be executed at the transition from "Operation enable" to "Switched on" (4 and 5).

| P 2220 | Designation in DM 5 | Function |
|---|---|---|
| POFF(0) | 0(0)= Disable power stage/drive function | Disable power stages; drive coasts to a stop |
| SDR(1) | 1(1)= Slow down with slow down ramp; disable of the drive function | The drive brakes with the programmed deceleration ramp, then the power stage is disabled |

## Response to stop option code / "Stop feed"

The "Stop feed" state brakes an ongoing movement for as long as the state is active. During braking the drive can be accelerated back to the previous state. When deactivated, the programmed acceleration ramp is again applied.

| P 2221 | Designation in DM 5 | Function |
|---|---|---|
| SDR(1) | 1(1)= Slow down on slow down ramp | The drive brakes with a programmed deceleration ramp |
| QSR(2) | 2(2)= Slow down on slow quickstop ramp | Braking with emergency stop ramp |
| CLIM(3) | 3(3)= Slow down on current limit | Braking with max. dynamics at current limit. The speed reference is set equal to 0. |
| Free(4) | - | |

### Response to "Fault Reaction Option Code"

| P 2222 | Designation in DM 5 | Function |
|---|---|---|
| SDR(1) | Disabled drive, motor is free to rotate | Disable power stages; the drive coasts to a stop |
| QSR(2) | Slow down on slow down ramp | The drive brakes with a programmed deceleration ramp |
| CLIM(3) | 3(3)= Slow down on current limit | Braking with max. dynamics at current limit. The speed reference is set equal to 0 |
| Free(4) | - | |

### Braking ramp for "Quickstop"

| P 2242 | Settings | MP_QuickStopDec: |
|---|---|---|
| 0 | 3000 | Setting of quick-stop ramp |

## 5.4 Homing

The drive-controlled homing runs are executed according to the CANopen drive profile DSP 402 as from V 2.0.

**Note:** These drive-controlled homing runs with the corresponding parameters are also used in the case of control via the SERCOS and PROFIBUS field buses and in conjunction with internal reference generation.

### 5.4.1 Drive-controlled homing

When relative encoder systems are used, the drive must be homed via bit 11 in control word 1. As soon as this bit is set by the master, the drive performs a position-controlled homing run using an internal profile generator taking into account homing speed, homing acceleration and the strategy stored in the homing method.

#### Homing speed

The homing speed is preset via parameter **P 2262 MPRO_402_HomingSpeeds** in the DriveManager. In this, the user has the possibility to specify two different homing speeds.

| P 2262 | MPRO_402_HomingSpeeds | Designation in DM 5 | Function |
|---|---|---|---|
| (0) | SpeedSwitch(0) | Speed during search for switch | Speed on the way to the limit switch |
| (1) | SpeedZero(1) | Speed during search for zero | Speed during travel to zero point |

#### Homing acceleration

The homing acceleration is preset via **P 2263 MPRO_402_HomingAcc** in the DriveManager.

#### Zeroing offset

Absolute encoders (e.g. SSI-Multiturn encoders) are a special feature in homing, because they establish the absolute position reference directly. Homing with these encoders therefore requires no movement and, under certain conditions, no current to the drive. Homing type -5 is recommended for the zero balancing. A zero offset can be set via parameter **P 0525 ENC_HomingOff**.

## Zero pulse evaluation

If a homing run is selected which requires evaluation of a zero pulse, the evaluation is automatically started in the background and automatically stopped when homing is complete. It is possible to plot the zero pulse on the scope for diagnostic purposes (Scope channel: Encoder Position Channel 1/3 Np).

## Reference cam, limit switch

The reference cam signal can be optionally linked to one of the digital inputs. Inputs ISD00 to ISD06 are available. In homing to a limit switch, the digital input must be selected with the available selection parameter LCW(5) for a positive or LCCW(6) negative limit switch. In homing to a cam, the selection parameter HOMSW(10) must be chosen (see parameters **P 0101–P 0107**).

| P.no. | Parameter name/ Setting | Designation in DM 5 | Function |
|---|---|---|---|
| P 2261 | P 0101 to P 0107 MPRO_INPUT_FSISDxx | MPRO_402_Homing-Method | Digital inputs |
| (-7) | - | Move pos. direction, for distance coded encoder | Homing method for increment-coded encoder for positive direction |
| (-6) | - | Move pos. direction, for distance coded encoder | Homing method for increment-coded encoder for negative direction |
| (-5) | - | Act. position + homing offset (multiturn-encoder) | Homing (absolute value encoder) |
| (-4) | HOMSW | Homing mode type 22 with continuous reference | Continuous homing, negative edge of reference cam |
| (-3) | HOMSW | Homing mode type 20 with continuous reference | Continuous homing, positive edge of reference cam |
| (-2) | - | No homing mode (act. position + homing offset) | No homing; only an offset adjustment is made |
| (-1) | - | Reference position = homing offset (parameter HOOFF) | Actual position=Zero |

| P.no. | Parameter name/ Setting | Designation in DM 5 | Function |
|---|---|---|---|
| P 2261 | P 0101 to P 0107 MPRO_INPUT_FSISDxx | MPRO_402_Homing-Method | Digital inputs |
| (0) | - | Not defined | No homing |
| (1) | LCCW | Neg. end switch, zero pulse | Homing negative limit switch and zero pulse |
| (2) | LCW | Pos. end switch, zero pulse | Homing positive limit switch and zero pulse |
| (3) | HOMSW | Pos. reference cams, zero pulse at RefCam=Low | Homing to cam negative edge, positive direction + zero pulse |
| (4) | HOMSW | Pos. reference cams, zero pulse at RefCam=High | Homing to cam positive edge, positive direction + zero pulse |
| (5) | HOMSW | Neg. reference cams, zero pulse at RefCam=Low | Homing to cam negative edge, negative direction + zero pulse |
| (6) | HOMSW | Neg. reference cams, zero pulse at RefCam=High | Homing to cam positive edge, negative direction + zero pulse |
| (7) to (14) | HOMSW | Left reference cam polarity, zero pulse at RefCam=Low | Various homing runs to cam |
| (15), (16) | - | not defined | Reserved |
| (17) | LCCW | Neg. end switch | Homing negative limit switch |
| (18) | LCW | Pos. end switch | Homing positive limit switch |
| (19) | HOMSW | Pos. reference cams, Stop at RefCam=Low | Homing to cam negative edge, positive direction |
| (20) | HOMSW | Pos. reference cams, Stop at RefCam=High | Homing to cam positive edge, positive direction |
| (21) | HOMSW | Neg. reference cams, Stop at RefCam=Low | Homing to cam negative edge, negative direction |
| (22) | HOMSW | Neg. reference cams, Stop at RefCam=High | Homing to cam positive edge, negative direction |
| (23) bis (30) | HOMSW | Left reference cam polarity, Stop at RefCam=Low | Various homing runs to cam |

| P.no. | Parameter name/ Setting | Designation in DM 5 | Function |
|---|---|---|---|
| P 2261 | P 0101 to P 0107 MPRO_INPUT_FSISDxx | MPRO_402_Homing-Method | Digital inputs |
| (31), (32) | - | Not defined | Reserved |
| (33) | - | Next left zero pulse | Zero pulse in negative direction |
| (34) | - | Left reference cam polarity, Stop at RefCam=High | Zero pulse in positive direction |
| (35) | - | Actual position = Reference position | Zero is current position |

## Homing method

The homing method is selected via parameter **P 2261 MPRO_402_HomingMethod** (type (-5) to type (35)).

The different homing methods are described in the following. The individual reference points corresponding to the zero are numbered in the graphs. The different homing speeds (V1=SpeedSwitch, V2=SpeedZero) and the directions of movement are also shown.

## Type -5: Absolute encoder:

This type is suitable for absolute encoders (e.g. SSI-Multiturn encoders). Homing is performed immediately after power-on. It can also be activated with the power disconnected.

The current position corresponds to the zero point. The zero position is calculated on basis of the absolute encoder position + zero offset.

Accordingly, in operation of a SSI-Multiturn encoder for example, homing with zero offset = 0 delivers the absolute position of the SSI encoder. Another homing run with unchanged setting of the zero offset does not cause a change in position.

**Homing or zero balancing of the system is performed as follows:**

1. Enter zero offset = 0
2. Homing (Start homing) delivers the absolute position of the encoder
3. Move drive to reference position (machine zero)
4. Then enter the zero offset (the value by which the position is to be changed relative to the displayed position)
5. Repeat homing (Start homing)
6. Save setting (zero offset)
7. At power-on the system is automatically homed. Manual homing is no longer necessary.

## Type -4: Ongoing homing, negative reference cam:

As homing method 22, with subsequent possibility of continuous homing. For more information see “Type -3”.

## Type -3: Ongoing homing, positive reference cam:

As homing method 20, with subsequent possibility of continuous homing. Types “-3” and “-4” can only be used with an infinite travel range. They are used for fully automated compensation for slip or inaccurate gear ratios. After initial homing the actual position is overwritten with the zero offset at every rising edge of the reference cam. The distance still to be travelled is corrected, enabling the axis to perform any number of relative movements in one direction without drifting, even with drives susceptible to slip.

The circumferential length must match the distance between two reference signals as closely as possible. In other words: The same position must be indicated again after one circulation, otherwise disturbing movements may occur during a correction. The permissible lag must be larger than the maximum mechanical inaccuracy.

Attention: Correction of the actual position is effected in steps. No acceleration ramps are active. The correction is this treated like a tracking error adjustment. The maximum speed of the positioning driving profile has no effect here.

### Type: -2, No homing is performed:

No homing is performed. The current position is added to the zero offset. The first time the power stage is switched on the "Homing completed" status is set. This method is suitable for absolute encoders, as long as no zero balancing is required. For zero balancing please select type -5.

### Type: -1, Actual position = 0:

The actual position corresponds to the zero. It is set to 0, i.e. the controller performs an actual position reset. The zero offset is added.

### Type: 0:

Not defined.

### Type: 1, Negative limit switch and zero pulse:

The initial movement is as shown in Figure 5.17 towards the negative (left) hardware limit switch (which is inactive) and the direction of movement is reversed when the edge is active. The first zero pulse after the falling edge corresponds to the zero.

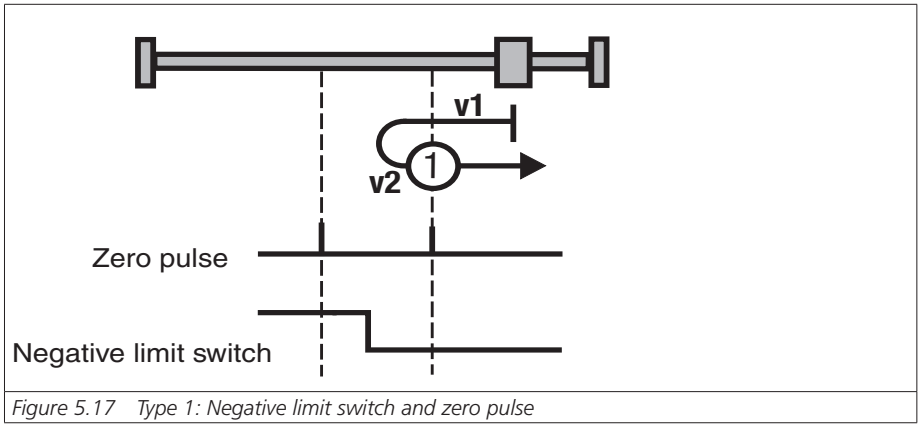



*Figure 5.17 Type 1: Negative limit switch and zero pulse*

### Type 2, Positive limit switch and zero pulse

The initial movement is as shown in figure 5.20 towards the positive (right) hardware limit switch (which is inactive) and the direction of movement is reversed when the edge is active. The first zero pulse after the falling edge corresponds to the zero.

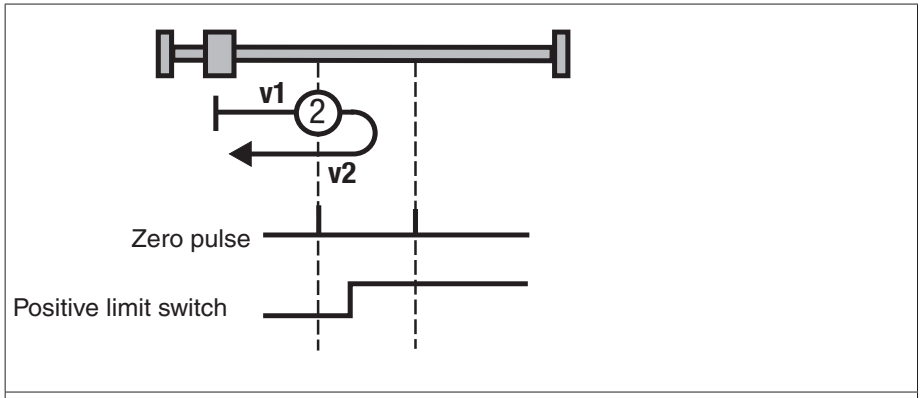



*Figure 5.18 Type 2: Positive limit switch and zero pulse*

### Type: 3+4, Positive reference cam and zero pulse

The initial movement is as shown in Figure 5.19 towards the positive (right) hardware limit switch, if the reference cam is inactive - see symbol A in Figure 5.19 .

As soon as the reference cam is active, the type 3 direction is reversed. The first zero pulse after the falling edge corresponds to the zero.

With type 4, the first zero pulse after the rising edge corresponds to the zero. The initial movement is towards the negative (left) hardware limit switch and the reference cam is active - see symbol B in Figure 5.19 .

If the reference cam becomes inactive, the first zero pulse of type 3 corresponds to the zero. With type 4, the direction reverses as soon as the reference cam becomes inactive. The first zero pulse after the rising edge corresponds to the zero.

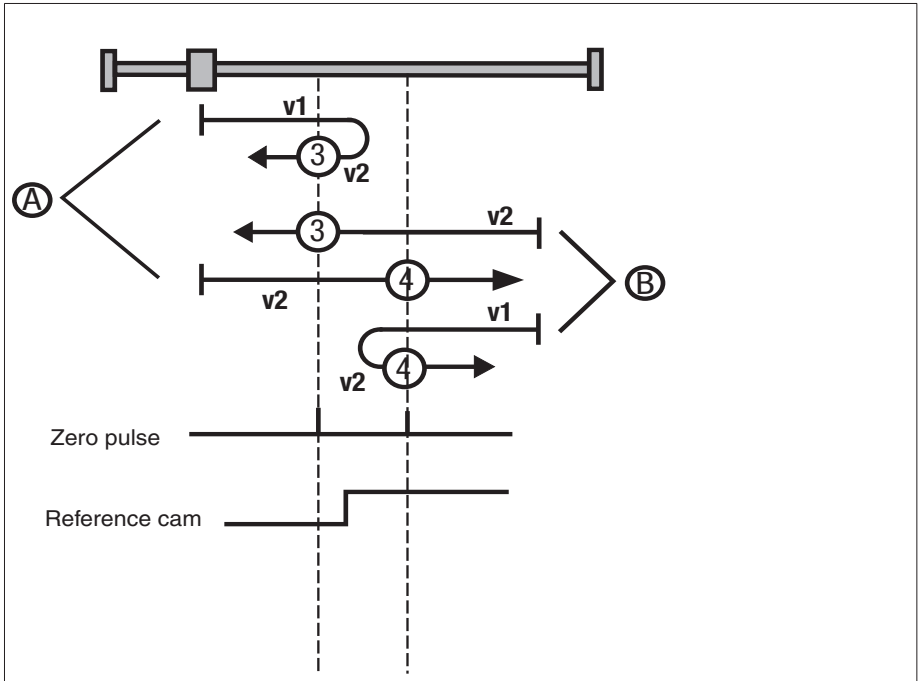



*Figure 5.19 Type 3+4: Positive reference cam and zero pulse*

## Type 5+6: Negative reference cam and zero pulse

The initial movement is towards the positive (right) hardware limit switch and the reference cam is active - see symbol A in Figure 5.20 .

With type 5 the first zero pulse after the falling edge corresponds to the zero.

When the reference cam becomes inactive, the type 6 direction is reversed and the first zero pulse after the rising edge corresponds to the zero. The initial movement is towards the negative (left) hardware limit switch and the reference cam is inactive - see symbol B in Figure 5.20 .

With type 5 the direction of movement is reversed as soon as the reference cam becomes active, and the first zero pulse after the falling edge corresponds to the zero.

For type 6 the first index pulse after the ascending flank corresponds with the zero point.

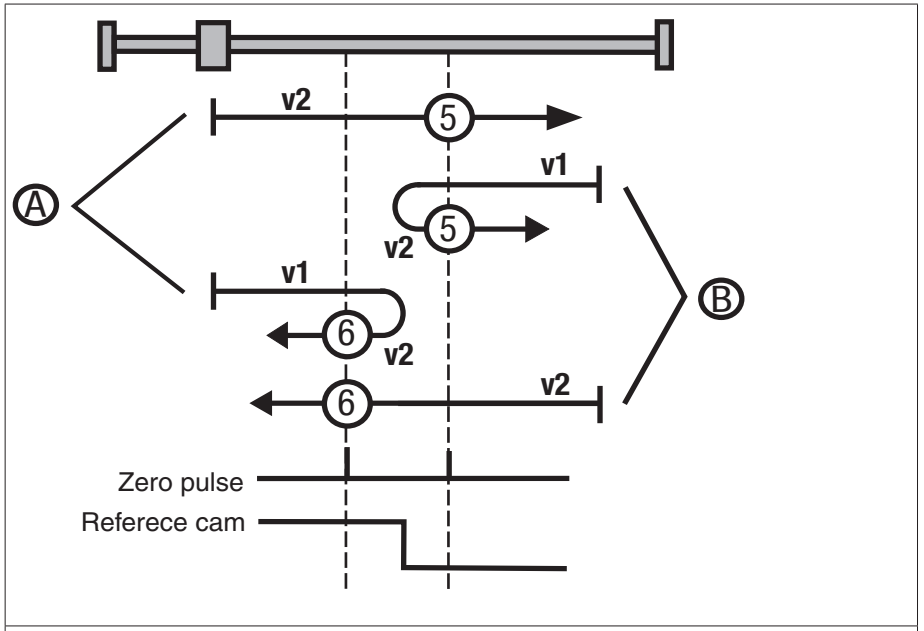



*Figure 5.20 Type 5+6: Negative reference cam and zero pulse*

## Homing method for increment-coded encoders:

Type -6: move negative direction for distance coded encoder-
Type -7: move positive direction for distance coded encoder-

## Type 7 to 10, Reference cam, zero pulse and positive limit switch

The initial movement is towards the positive (right) hardware limit switch. It and the reference cam are inactive (see symbol A in figure 5.23). Type 7 reverses the direction of movement after an active reference cam. The zero corresponds to the first zero pulse after a falling edge. With type 8 the zero corresponds to the first zero pulse with an active

reference cam. Type 9 reverses the direction of movement if the reference cam has been overrun. The zero corresponds to the first zero pulse after the rising edge. With type 10 the reference cam is overrun and the first zero pulse after that corresponds to the zero.

The initial movement is towards the negative (left) hardware limit switch. The positive limit switch is inactive and the reference cam is active - see symbol B in figure 5.23.

With type 7 the zero corresponds to the first zero pulse after a falling edge of the reference cam. Type 8 reverses the direction of movement after a falling edge of the reference cam. The zero corresponds to the first zero pulse after the rising edge of the reference cam.

The initial movement is towards the positive (right) hardware limit switch. It is inactive and the reference cam is active - see symbol C in figure 5.23.

Type 9 reverses the direction of movement if the reference cam is inactive. The zero corresponds to the first zero pulse after the rising edge. With type 10 the first zero pulse after a falling edge of the reference cam is the zero point.

The initial movement is towards the positive (right) hardware limit switch. It and the reference cam are inactive. As soon as the positive limit switch becomes active, the direction of movement is reversed - see symbol D in figure 5.23.

With type 7 the first zero pulse after overrunning the reference cam corresponds to the zero.

Type 8 reverses the direction of movement if the reference cam has been overrun. The zero corresponds to the first zero pulse after the rising edge.

With type 9 the zero corresponds to the first zero pulse with an active reference cam.

Type 10 reverses the direction of movement after an active reference cam. The zero corresponds to the first zero pulse after a falling edge.

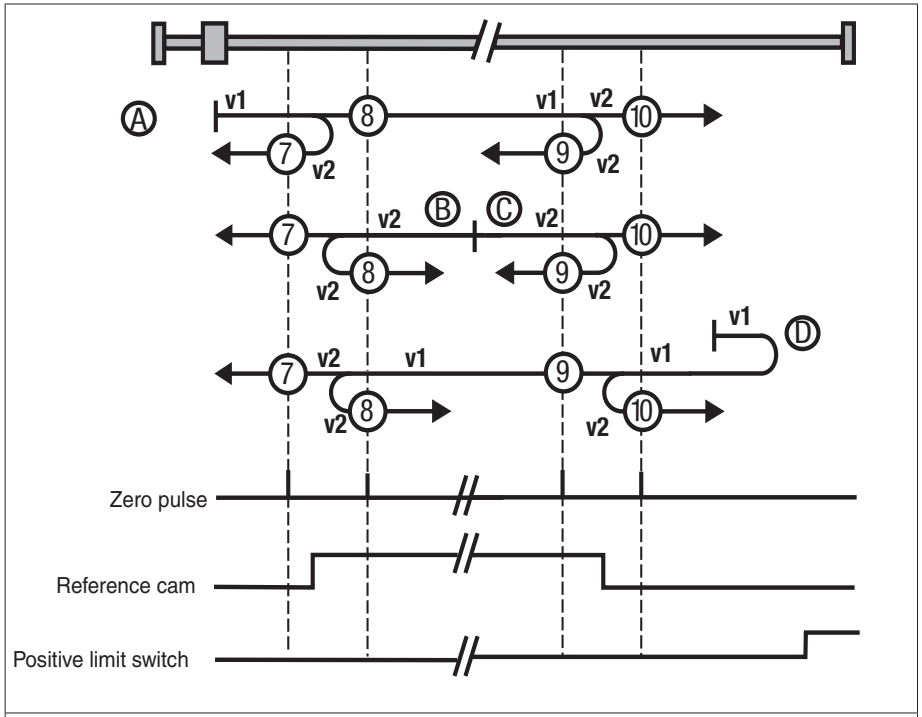



*Figure 5.21 Type 7 to 10: Reference cam, zero pulse and positive limit switch*

## Type 11 to 14, Reference cam, zero pulse and negative limit switch

The initial movement is towards the negative (left) hardware limit switch. It and the reference cam are inactive - see symbol A in figure 5.24.

Type 11 reverses the direction of movement after an active reference cam. The zero corresponds to the first zero pulse after a falling edge. With type 12 the zero corresponds to the first zero pulse with an active reference cam.

Type 13 reverses the direction of movement if the reference cam has been overrun. The zero corresponds to the first zero pulse after the rising edge.

With type 14 the reference cam is overrun and the first zero pulse after that corresponds to the zero.

The initial movement is towards the negative (left) hardware limit switch. It is inactive and the reference cam is active - see symbol B in figure 5.24.

Type 13 reverses the direction of movement if the reference cam is inactive. The zero corresponds to the first zero pulse after the rising edge. With type 14 the first zero pulse after a falling edge of the reference cam is the zero point.

The initial movement is towards the positive (right) hardware limit switch. The positive limit switch is inactive and the reference cam is active - see symbol C in figure 5.24.

With type 11 the zero corresponds to the first zero pulse after a falling edge of the reference cam. Type 12 reverses the direction of movement after a falling edge of the reference cam. The zero corresponds to the first zero pulse after the rising edge of the reference cam.

The initial movement is towards the negative (left) hardware limit switch. It and the reference cam are inactive. As soon as the negative limit switch becomes active, the direction of movement is reversed - see symbol D in figure 5.24.

With type 11 the reference cam must be overrun, then the first zero pulse corresponds to the zero.

Type 12 reverses the direction of movement if the reference cam has been overrun. The zero corresponds to the first zero pulse after the rising edge.

With type 13 the zero corresponds to the first zero pulse with an active reference cam.

Type 14 reverses the direction of movement after an active reference cam. The zero corresponds to the first zero pulse after a falling edge.

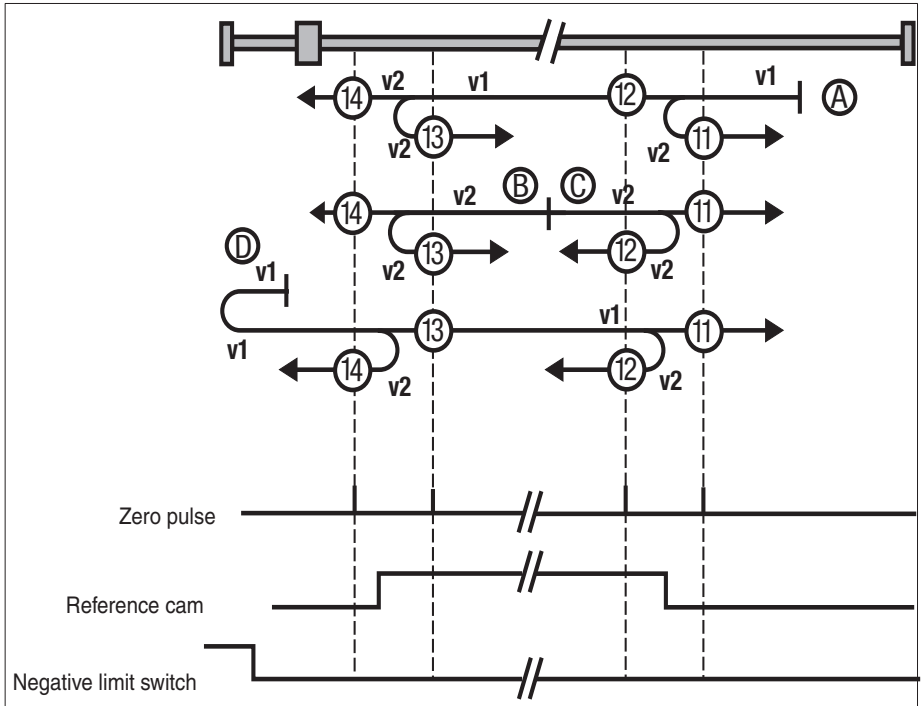



*Figure 5.22 Type 11 to 14: Reference cam, zero pulse and negative limit switch*

## Type 15 and 16

These homing methods are not defined.

## Type 17 to 30, Reference cam

Homing method types 17 to 30 are similar to types 1 to 14. Determination of the zero point does not depend on the zero pulse, but solely on the reference cam or the limit switches.

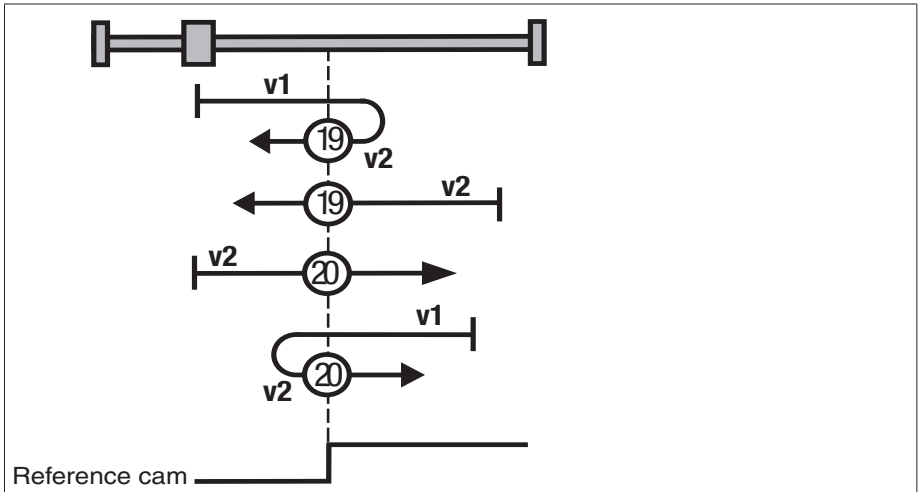



*Figure 5.23 Type 17 to 30: Reference cam*

Type comparison for the individual homing methods

| | |
|---|---|
| Type 1 corresponds to type 17 | Type 12 corresponds to type 28 |
| | |
| Type 4 corresponds to type 20 | Type 14 corresponds to type 30 |
| | |
| Type 8 corresponds to type 24 | |
| | |

### Type 31 and 32

These homing methods are not defined.

### Type 33 and 34, Zero pulse

The zero corresponds to the first zero pulse in the direction of movement.

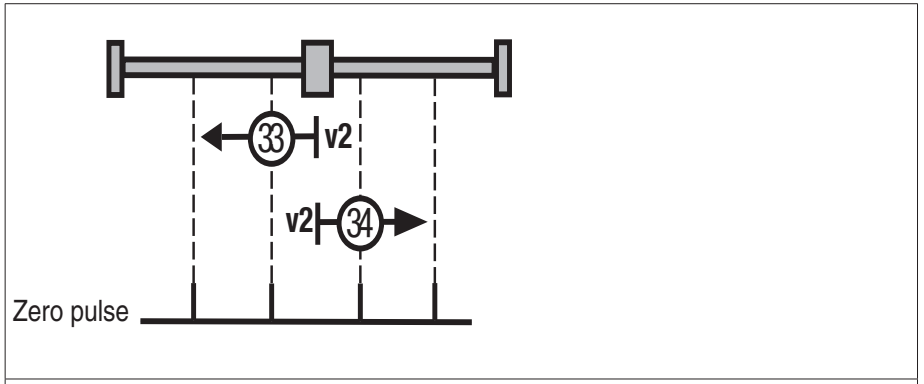



*Figure 5.24 Type 33 + 34: Zero pulse*

### Type 35

The current actual position corresponds to the zero.

## 5.5 Jog mode

Jog mode enables the drive to be moved manually. A bus system or reference sourcing via terminal can be selected as the reference. The unit corresponds to the selected user unit. It is possible to select fast and a slow jog speeds in both directions. For jogging in positive and negative direction two digital input parameters must be set to INCH_P(7) = Jog + and INCH_P(8) = Jog -. For jogging at different speeds, both switches must be activated. If the "Jog left" switch is activated first and then switch two, quick jog mode left is started. If the "Jog right" switch is activated first, quick jog mode right is started.

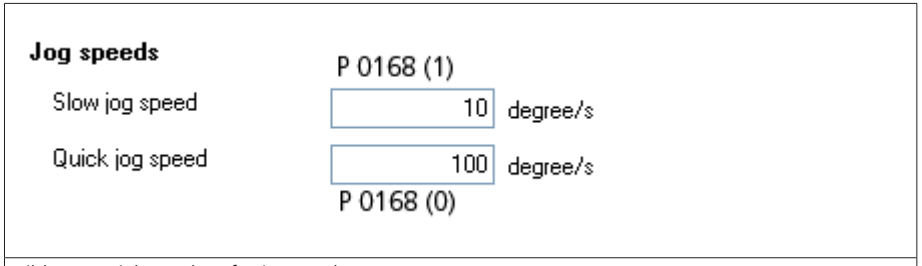



*Bild 5.1 Dialogue box for jog mode*

## 5.6 Table references

Fixed speeds, fixed torques or a fixed position can be preset by way of a table. A travel profile is generated internally using the Profile Generator. The 16 table values can be selected using the on-screen slider.

Reference input for fixed positions:
Each position value is assigned a speed and acceleration and braking ramps.

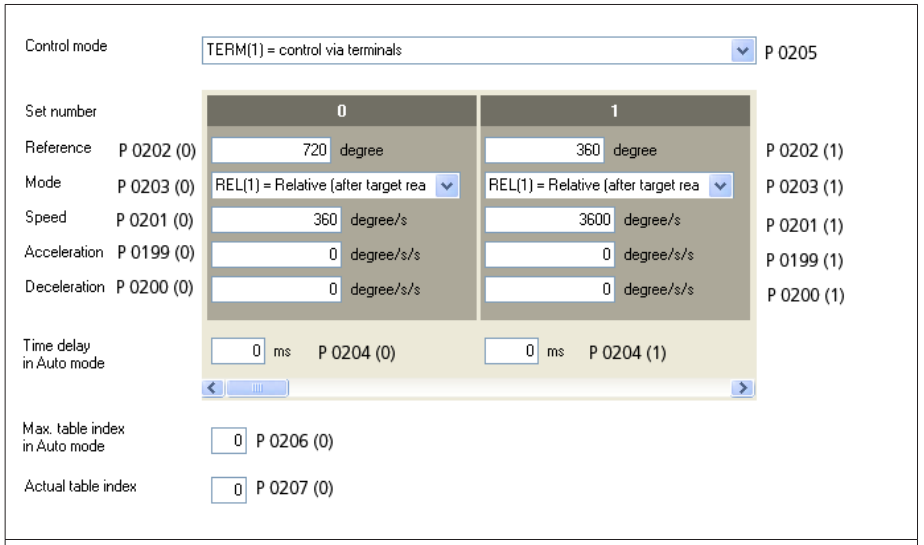



*Bild 5.2 Reference table screen*

There are 16 driving sets (0-15)

| P.no. | Index | Parameter name/ Settings | Designation in DM 5 | Function |
|---|---|---|---|---|
| P 0199 | 0-15 | MPRO_TAB_PAcc | Position mode acceleration | Acceleration ramp |
| P 0200 | 0-15 | MPRO_TAB_PDec | Position mode deceleration | Braking ramp |
| P 0201 | 0-15 | MPRO_TAB_PSpd | Position mode speed | Velocity |
| P 0202 | 0-15 | MPRO_TAB_PPos | Position mode reference position | Reference |
| P 0203 | 0-15 | MPRO_TAB_PMode | Position mode | Positioning mode |
| (0) | | ABS(0) | Absolut | Absolute positioning |
| (1) | | REL(1) | Relative, after target reached | Relative positioning after target position reached |

| P.no. | Index | Parameter name/ Settings | Designation in DM 5 | Function |
|---|---|---|---|---|
| (2) | | REL at once(2) | Relative at once | The current motion task is interrupted and a new pending task is directly accepted and executed. |
| (3) | | SPEED(3) | Endless, Speed controlled | Endless motion, SPD (endless motion task): If a table value is set to SPD, an endless motion task is transmitted. If a table value with the setting ABS or REL is additionally selected, the endless task is quit and the newly selected table value is approached from the current position. |
| P 0204 | 0-15 | MPRO_TAB_Wait time | Max time for position or speed control | With follow-up tasks: Wait time until execution of the next motion task |
| P 0205 | | MPRO_TAB_Mode | Operation mode | Selection of table values |
| (0) | | PARA(0) | Control via parameter **P0207** | Selection of a table value via **P 0207** |
| (1) | | TERM(1) | Control via terminals | Selection of a table value via terminal |
| (2) | | AUTO(2) | Control via timer, **P 0204** | Selection of a table value via terminal **P 0204** |
| (3) | | BUS(2) | Control via fieldbus | Selection of a table value via field bus system |
| P 0206 | | MPRO_TAB_MaxIdx | Max Index im AUTO Mode | Setting for number of table values to be worked through in sequence from top to bottom. Example: If this value is set to 6, the first six reference values from the table are worked through in sequence. This process is repeated until the table is disabled or the start contact is removed. |
| P 0207 | | MPRO_TAB_ActIdx | Actual Index | Display of the currently selected motion task |

Note: Before a driving set can be executed, the data set is first selected. Then it must be read-in. If the activation is via terminal, this is done with a digital input parameterized to “TBEN”. A motion task is selected via field bus by setting the corresponding bits (see SERCOS/CANopen user manual).

Note: The driving sets contain predefined standard units. So before configuring the driving set parameters the units and scaling must first be checked. Once the reference source has been selected from the table, parameter **P 0283 MPRO_FG_Type must be set to >USER** (see section 5.1, Scaling).

### Selection of driving sets:

| Activation | Setting | Description |
|---|---|---|
| Triggering via terminal _ I/O configuration | Input ISDxx = TBEN | Enabling a selected driving set The selection of a new motion task always interrupts an ongoing positioning or follow-up task logic. |
| Triggering via terminal _ I/O configuration | Input ISDxx = TAB0 to TAB3 | The binary significance (20, 21 , 22 , 23) results from the TABx assignment. The TAB0 setting has the lowest significance (20), and the TAB3 the highest (23). A Logical 1 level at the input activates the significance. |
| Triggering via field bus system | Cross-check "Execute motion task" bit with control word!!! | Enabling a selected driving set The selection of a new motion task always interrupts an ongoing positioning or follow-up task logic. |
| Triggering via field bus system | Cross-check "Activate follow-up task" bit with control word!!! | The binary significance (20, 21 , 22 , 23) results from the TABx assignment of the control word. The TAB0 setting has the lowest significance (20), and the TAB3 the highest (23). |

### Table settings dependent on control mode:

| Control mode | Table reference | Acceleration ramp | Braking ramp | Velocity | Positioning mode |
|---|---|---|---|---|---|
| Torque | P 0195 | P 0193 | P 0194 | | |
| Speed | P 0198 | P 0196 | P 0197 | | |
| Position | P 0202 | P 0199 | P 0200 | P 0201 | P 0203 |

### Reference setting:

Motion Control provides references in user-defined travel units. These values must be converted into internal units. This is done by way of the scaling block "Standardisation/ units".

There are three options for scaling of the drive controller: The selection is made via **P 0283 MPRO_FG_Type** (for more information see "Scaling" section).

### Velocity:

The speed can be specified signed. A negative setting is only evaluated in case of endless positioning. It is limited by the parameter **P 0328 CON_SCON_SMax**.

## Starting and braking

The acceleration values for starting and braking can be parameterized independently of each other. The input must not be zero. Accelerations are controlled by the limitations.

### Follow-up task:

The motion tasks from zero up to the value set in **P 0206** "Number of follow-up tasks to be processed" are continuously processed. Once the driving set in **P 0206** is finished, the first data set is restarted. Processing is only stopped by removing the start contact. If a task has the setting REL at once, the driving set can be aborted and a new one can be started immediately.

### Driving sets in speed control

Each driving set, either for speed or torque, has an acceleration and a braking ramp.

| P.no. | Index | Parameter name/ Settings | Designation in DM 5 | Function |
|---|---|---|---|---|
| P-0196 | 0-15 | MPRO_TAB_SAcc | Speed mode acceleration | Acceleration ramp |
| P-0197 | 0-15 | MPRO_TAB_SDec | Speed mode deceleration | Braking ramp |
| P 0198 | 0-15 | MPRO_TAB_SRef | Speed mode reference value | Reference |

### Driving sets in torque control

| P.no. | Index | Parameter name/ Settings | Designation in DM 5 | Function |
|---|---|---|---|---|
| P-0193 | 0-15 | MPRO_TAB_TAcc | Torque mode acceleration | Acceleration ramp |
| P-0194 | 0-15 | MPRO_TAB_TDec | Torque mode deceleration | Braking ramp |
| P 0195 | 0-15 | MPRO_TAB_TRef | Torque mode reference value | Reference |

## 5.7 Analog channel ISA0x

To be able to specify reference setpoints for the control via the two analog inputs ISA0 and ISA1, the following function selectors must be set accordingly.

Setting of analog input ISA0/1:
**P 0109, P 0110** must each be set to REV(-2). The functions usable in analog mode are indicated by a (-) mark (see "I/O configuration" section).

| P. no. | Parameter name/ Settings | Designation in DM 5 | Function |
|---|---|---|---|
| P 0109<br>P 0110 | MPRO_INPUT_FS_ ISA0/1 | Function of analog input ISA0/1 | Function of the analog input |
| | REFV(-2) | Analog command | The analog reference can be passed on to the control |
| P 0165 | MPRO_REF_SEL | Motion profile selection | Reference selector |
| | ANA0/1 | Via analog channel ISA00 | Selection of the analog reference source |

Depending on the parameterized control mode (**P 0300 CON_CfgCon**), a speed or a torque can be set as the reference.

Structure diagram:

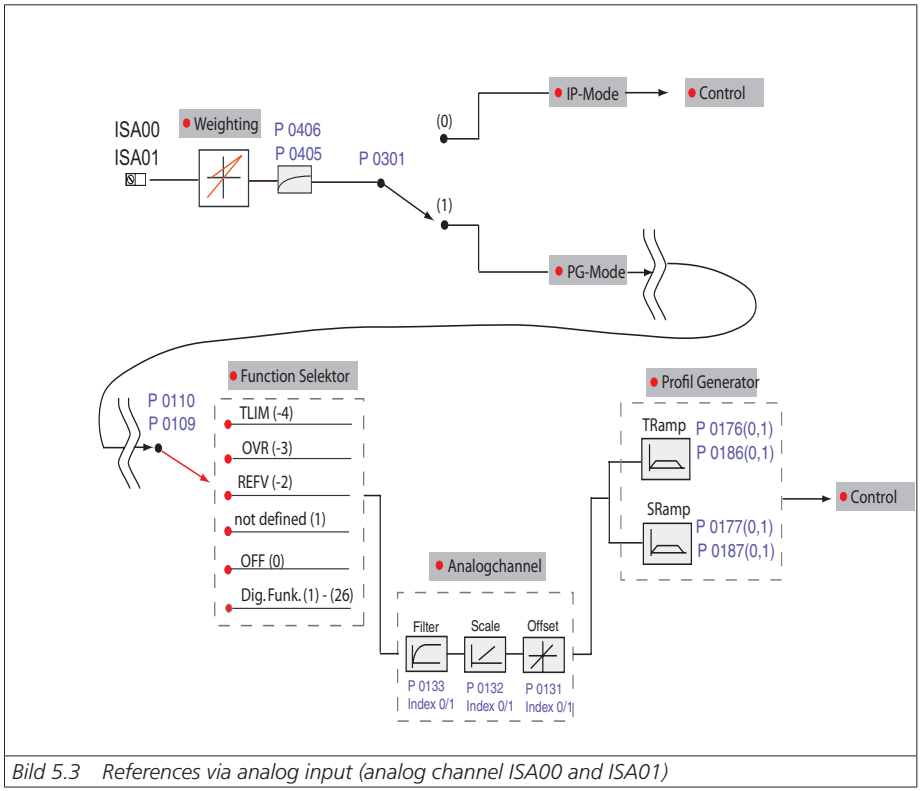



*Bild 5.3 References via analog input (analog channel ISA00 and ISA01)*

Parameters for reference processing are available for all control modes (torque, speed and position control). The scaling, weighting, an offset and a threshold (backlash) are programmable. The parameters are described in the following sections. The reference can also be filtered via parameters **P 0405 CON_ANA_Filt0** and **P 0406 CON_ANA_Filt1**.

Note: For additional information on PG and IP modes refer to the Motion control section, 5.2.3/Profile generator/Interpolated mode.

## 5.7.1 Reference input via analog inputs (IP/PG mode)

The parameter **P 0301 CON_REF_Mode** is used to determine whether the analog references are specified via the ramp generator (setting PG(0)) or directly (setting IP(1)).

If direct input via IP mode is selected, only the input filters are active. The analog values are in this case scanned and filtered in the current control cycle and then directly transferred as references for the speed or torque control. This is the mode to set, for example, if the position controller (or speed controller) is implemented in a higher-level controller and transfers the speed references (or torque references) to the drive controller via the analog input.

### Scale/offset/backlash function, ramps

At start of configuration the +/- 10 V is assigned (Scale) to the maximum reference value (e.g. 3000 rpm). Component spread is compensated by way of the offset function and the Backlash setting defines a backlash range. The setting for specifying torque references is made via the analog channel, as in speed control. The braking and acceleration ramp corresponds to the ramp for torque rise and fall.

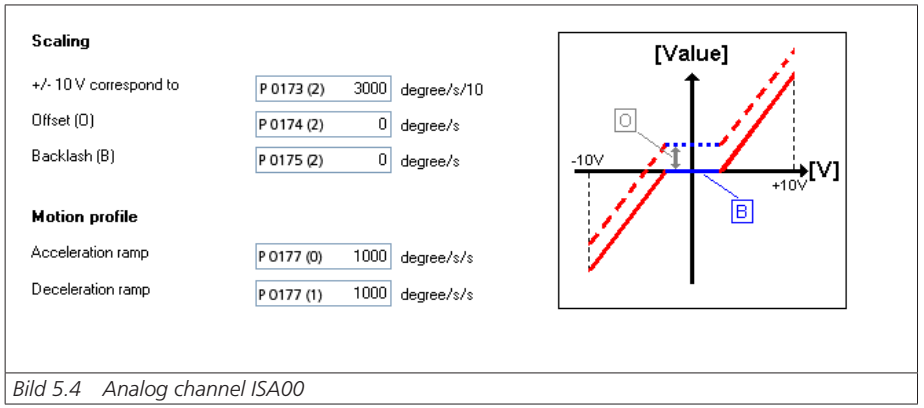



*Bild 5.4 Analog channel ISA00*

| P.no. | Parameter name/ Settings | Designation in DM 5 | Function |
|---|---|---|---|
| P 0173<br>P 0183 | MPRO_ANA0_Scale | scale factors | Scaling/weighting: |
| (0) | TScale | scale factor for torque reference | Scaling for the torque reference (Nm/10 V) |
| (1) | SScale | scale factor for speed reference | Scaling for the speed reference (rpm / 10 V) |
| (2) | PScale | scale factor for position reference | Scaling for the position reference (user unit/10 V) |
| P 0174<br>P 0184 | MPRO_ANA1_OFF | Offset | Reference offset (Nm) |
| (0) | TOffset | Offset for torque reference | Offset for the torque reference (Nm) |
| (1) | SOffset | Offset for Speed reference | Offset for the speed reference |
| (2) | POffset | Offset for position reference | Offset for the position reference (user unit) |
| P 0175<br>P 0185 | MPRO_ANA1_Thresh | threshold | Backlash |
| (0) | TThreshold | Threshold for torque reference | Backlash for the torque reference (Nm) |
| (1) | SThreshold | Threshold for speed reference | Backlash for the speed reference |
| (2) | PThreshold | Threshold for position reference | Backlash for the position reference (user unit) |

| P.no. | Parameter name/ Settings | Designation in DM 5 | Function |
|---|---|---|---|
| P 0176<br>P 0186 | MPRO_ANA0_TRamp | acceleration ramp(0) and deceleration ramp (1) | Acceleration ramp (0), braking ramp (1) |
| (0) | TRamp | Torque acceleration ramp | Torque acceleration ramp |
| (1) | TRamp | Torque deceleration ramp | Torque braking ramp |
| P 0177<br>P 0187 | MPRO_ANA0_SRamp | Speed mode acceleration (0) and deceleration (1) | Acceleration and braking ramp |
| (0) | SRamp | Speed acceleration ramp | Speed acceleration ramp |
| (1) | SRamp | Speed deceleration ramp | Speed breaking ramp |
| P 0405<br>P 0406 | CON_ANA_Filt0 | filter time | Filter time for analog input (0-100 ms) |

The reference can be filtered via parameter **P 0405 CON_ANA_Filt0**.

## 5.8 Touch probe

The touch probe function is described in section 9 of the SERCOS User Manual.

# 6. Inputs/outputs

## 6.1 Digital inputs

All digital inputs of the controller are set by way of a function selector. By this selector a unique function can be assigned to each input. Other settings can be made by clicking the **>Options** button.

Function selector for the digital inputs:

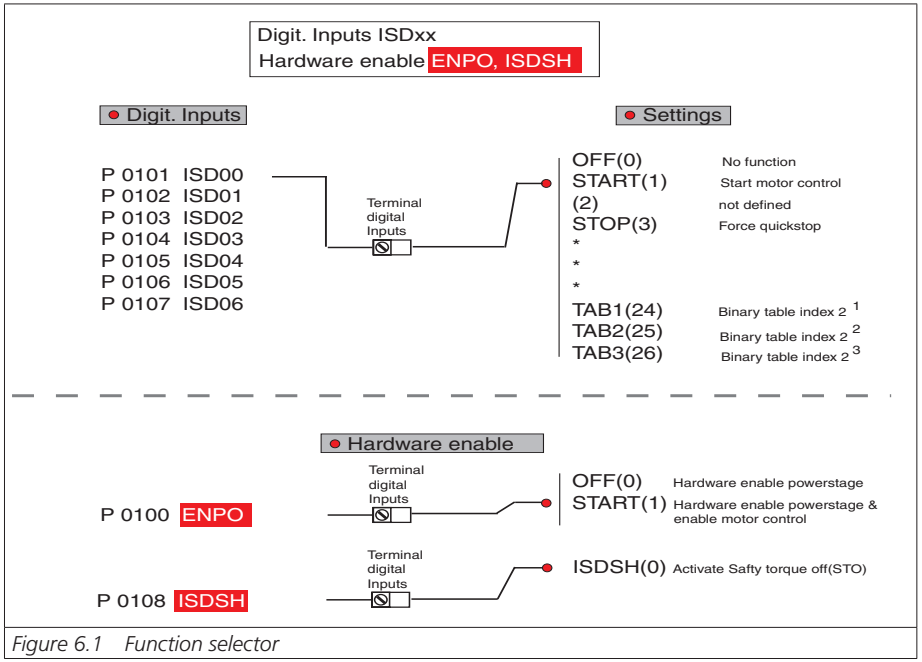



*Figure 6.1 Function selector*

Dialogue boxes for the digital inputs:

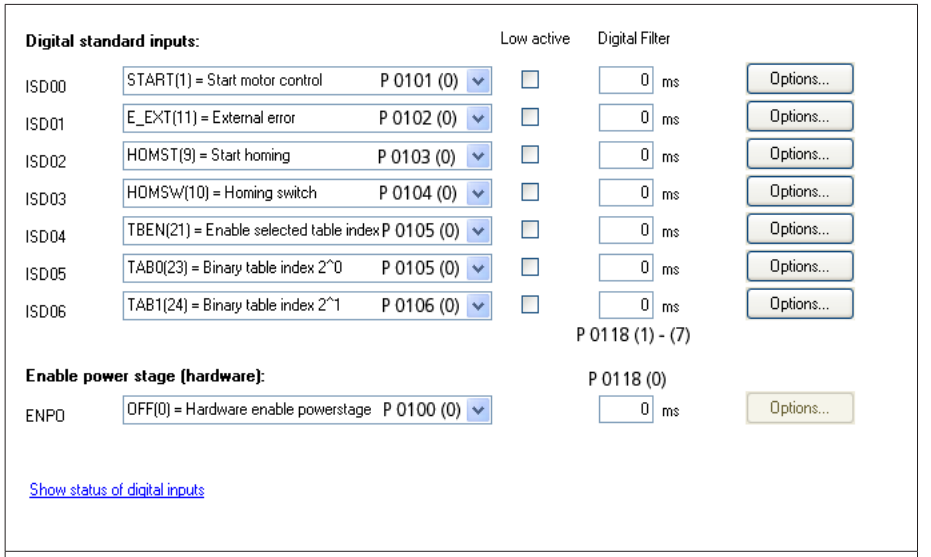

Digital standard inputs:
Low active
Digital Filter
ISD00 START(1) = Start motor control P 0101 (0) 0 ms Options...
ISD01 E_EXT(11) = External error P 0102 (0) 0 ms Options...
ISD02 HOMST(9) = Start homing P 0103 (0) 0 ms Options...
ISD03 HOMSW(10) = Homing switch P 0104 (0) 0 ms Options...
ISD04 TBEN(21) = Enable selected table index P 0105 (0) 0 ms Options...
ISD05 TAB0(23) = Binary table index 2^0 P 0105 (0) 0 ms Options...
ISD06 TAB1(24) = Binary table index 2^1 P 0106 (0) 0 ms Options...
P 0118 (1) - (7)
Enable power stage (hardware):
P 0118 (0)
ENPO OFF(0) = Hardware enable powerstage P 0100 (0) 0 ms Options...
Show status of digital inputs

*Figure 6.2 Dialogue box for the digital inputs:*

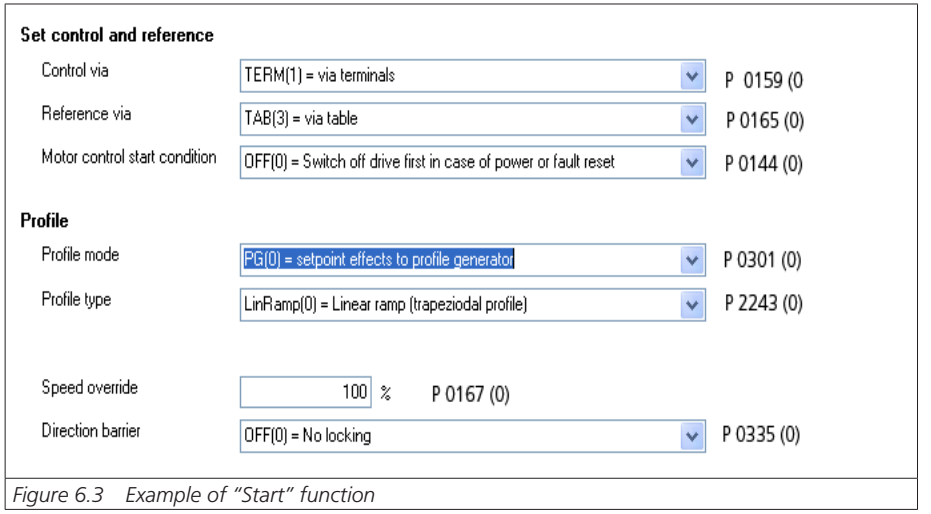

Set control and reference
Control via TERM(1) = via terminals P 0159 (0
Reference via TAB(3) = via table P 0165 (0)
Motor control start condition OFF(0) = Switch off drive first in case of power or fault reset P 0144 (0)
Profile
Profile mode PG(0) = setpoint effects to profile generator P 0301 (0)
Profile type LinRamp(0) = Linear ramp (trapeziodal profile) P 2243 (0)
Speed override 100 % P 0167 (0)
Direction barrier OFF(0) = No locking P 0335 (0)

*Figure 6.3 Example of "Start" function*

Seven digital inputs (ISD00 to ISD06) can be assigned a wide variety of functions via parameters **P 0101 to P 0107**. The two inputs ISDSH STO "Safe Torque Off" and ENPO "Enable Power" are reserved for the hardware enable. For the touch probe function the two "fast" inputs ISD05 and ISD06 are provided.

Overview of function selectors:

| P. no. | Parameter name/ Settings | Designation in DM 5 | Function |
|---|---|---|---|
| P 0100 | MPRO_INPUT_FS_ENPO | Function of digital input ENPO | Setting of hardware input ENPO |
| | OFF(0) | Hardware enable powerstage | The digital input ENPO (terminal 10 on X4) is reserved for hardware enable. In its default setting "OFF" it only executes the "Hardware enable" function. Apart from this, it can also be assigned the "START" function. In combination with parameter P 0144 DRVCOM AUTO_START= "LEVEL", autostart mode is active.<br>If STO is active, activation of the hardware enable ENPO via terminal 10 on X4 is sufficient to switch on the drive control (section 6.1.4) |
| | START(1) | | |
| P 0101 | MPRO_INPUT_FS_ISD00 | Function of digital input ISD00 | Settings for the digital inputs ISD00 – ISD06 are listed in the following table. |
| P 0102 | MPRO_INPUT_FS_ISD01 | Function of digital input ISD01 | |
| P 0103 | MPRO_INPUT_FS_ISD02 | Function of digital input ISD02 | |
| P 0104 | MPRO_INPUT_FS_ISD03 | Function of digital input ISD03 | |
| P 0105 | MPRO_INPUT_FS_ISD04 | Function of digital input ISD04 | Settings for the digital inputs ISD00 – ISD06 are listed in the following table. |
| P 0106 | MPRO_INPUT_FS_ISD05 | Function of digital input ISD05 | |
| P 0107 | MPRO_INPUT_FS_ISD06 | Function of digital input ISD06 | |
| P 0108 | MPRO_INPUT_FS_ISDSH | Function of digital input ISDSH | Reserved for STO (Safe torque off), (see also Inputs/outputs section) |
| P 0109 | MPRO_INPUT_FS_ISA00 | Function of analog input ISA00 | Analog input ISA00 see Analog inputs section |
| P 0110 | MPRO_INPUT_FS_ISA01 | Function of analog input ISA01 | Analog input ISA01 see Analog inputs section |

## 6.1.1 Settings for digital inputs ISD00-ISD06

| P.no. P 0101-P 0107 | Parameter name/ Settings | Function |
|---|---|---|
| (0) | OFF | Input off |
| (1) | START | Start of closed-loop control – motor is energized. The direction of rotation depends on the reference |
| (2) | (2) | Not defined |
| (3) | STOP | Quick stop according to quick stop reaction (Low active) see "Reactions in case of quick stop" |
| (4) | STOP | The running movement of the axis is interrupted according to the STOP reaction (see "Reactions in case of STOP feed") is interrupted and continued when reset. |
| (5) | LCW | Limit switch evaluation without override protection. The response to limit switch activation and to interchange limit switches is programmable (see "Error reactions, alarms, warnings" section) |
| (6) | LCCW | Limit switch evaluation without override protection. The response to limit switch activation and to interchange limit switches is programmable (see "Error reactions, alarms, warnings" section) |
| (7) | INCH_P | In manual positioning the axis can be moved in creep speed or in rapid motion |
| (8) | INCH_N | In manual positioning the axis can be moved in creep speed or in rapid motion |

| P.no. P 0101-P 0107 | Parameter name/ Settings | Function |
|---|---|---|
| (9) | HOMST | Start homing: according to the homing method parameterized in P 02261 MPRO_402_Homing Method |
| (10) | HOMSW | For zero point definition in positioning |
| (11) | E-Ext | Error messages from external devices cause an error message with the reaction determined in parameter P 0030 Error-Reaction Sub Index 11 |
| (12) | WARN | External collective warning |
| (13) | RSERR | Error messages are reset with an ascending flank, if the error is no longer present |
| (14) | MAN | In field bus operation switching of the reference source P 0165 CON_CfgCon and the control location P 0159 MPRO_CTRL to Term can be set via a digital switch. |
| (15) | PROBE | Only adjustable for the fast inputs ISD05 and ISD06 |
| (16) | PLC | Placeholder, inputs can always be read, irrespective of the setting |
| (17) | PLC_IR | Interruption of the program |
| (18) | (18) | Not defined |
| (19) | (19) | Not defined |
| (20) | (20) | Not defined |
| (21) | TBEN | Import and execution of selected table driving set |
| (22) | TBTBA | Teach in for position driving set table |
| (23) | TAB0 | Binary driving set selection (Bit 0) , (significance 20) for speed |
| (24) | TAB1 | Binary driving set selection (Bit 1) , (significance 21) for speed or positioning |
| (25) | TAB2 | Binary driving set selection (Bit 2) , (significance 22) for speed or positioning |
| (26) | TAB3 | Binary driving set selection (Bit 3) , (significance 23) for speed or positioning |

### 6.1.2 Hardware enable ISDSH STO (Safe Torque Off)

For the function "Save Torque Off" STO acc. to EN 954-1 "Category 3", under due consideration of the requirements specified in EN 61508 concerning the fulfillment of the systematic integrity for SIL2, the drive controllers are equipped with an integrated circuit with feedback contact. The logic cuts the power supply to the pulse amplifiers to activate the power stage. Combined with the "ENPO" controller enable, a two-channel block is placed on the occurrence in the power circuit of a pulse pattern suitable to generate a rotating field in the motor.

When the "ENPO" is cancelled the motor runs uncontrolled.

Function test: The STO function (protection against unexpected starting) must essentially be checked to ensure it is operative.

- During initial commissioning
- After any modification of the system wiring
- After replacing one or more items of system equipment.
- When the STO is cancelled the motor runs uncontrolled.

The drive controller has its own relay contact for feedback (terminal RSH on x4).

Attention: The machine manufacturer is responsible for determining the safety category required for an application (minimizing risk).

### 6.1.3 Hardware enable and autostart

The digital input ENPO (terminal 10 on X4) is reserved for hardware enable. In its default setting "OFF" it only executes the "Hardware enable" function. Apart from this, it can also be assigned the "START" function. In combination with parameter **P 0144 DRVCOM AUTO_START= "LEVEL"**, autostart mode is active.

If the "Safe Stop" function is active, the activation of the hardware enable ENPO via terminal 10 on X4 suffices to switch on the drive control.

When the "ENPO" is cancelled the drive runs down freely.

#### Power-up sequence

Regardless of which control mode was selected, the power-up sequence must be followed in order to start the drive.

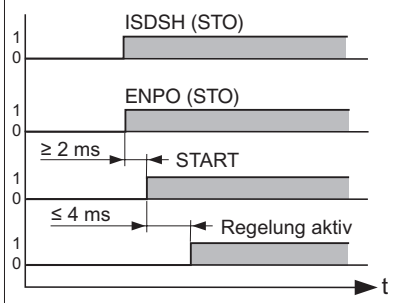
| Power-up sequence | Command | System state |
|---|---|---|
|  | STO ISDSH<br>ENPO-Enable Power<br>FS_ISDXX or Start. BIT= START(1)<br>control active | 2) Switch-on inhibit<br>(3) Ready to switch on<br>(4) Switched on<br>(5) Control active |

*Figure 6.4 Starting sequence for control*

If the power-up sequence as shown in figure 6.49 is followed, the drive starts with a rising edge of the digital input parameterized to START or when the corresponding Start bit is set via a bus system. The reference polarity determines the direction of rotation.

### 6.1.4 Manual drive control via digital inputs

Setting a digital input to "MAN(14)" allows a change of control location to the reference source selected in **P 0164 MPRO_REF_SEL_MAN**. This enables fast switching to manual control for setup or emergency running mode for example.

| P.no. | Parameter name/ Settings | Designation in DM 5 | Function |
|---|---|---|---|
| P 0164 | MPRO_INPUT_FS_ISDx | Function of digital input | Function selection |
| (0) | OFF | No profile selected | No profile selected |
| (1) | ANA0 | Profile via channel analog 0 | Reference value of analog input ISA0 |
| (2) | ANA1 | Profile via channel analog 1 | Reference value of analog input ISA1 |
| (3) | TAB | Profile via table positioning | Reference from table |
| (4) | (4) | not defined | vacant |
| (5) | PLC | Profile via PLC definition | Reference from PLC |
| (6) | PARA | Profile via parameter definition | Reference via parameter |
| (7) | DS402 | Profile via DS402 definition | Reference via CIA402 IE1131 |
| (8) | SERCOS | Profile via SERCOS definition | Reference via SERCOS |
| (9) | PROFI | Profil via PROFIBUS definition | Reference via DriveCom |
| (10) | VARAN | Profil via VARAN definition | Reference via VARAN |
| (11) | TWIN | Profil via TechOption definition | Reference via external option |

Required parameters

| P. no. | Parameter name/ Settings | Designation in DM 5 | Function |
|---|---|---|---|
| P 0101 - P 0107 | MPRO_INPUT_FS_ISD00 - ISD06 | Function of digital input | Set digital input to MAN(14) |
| P 0159 | MPRO_CTRL_SEL | Motion control selection | The control mode must not be changed when switching reference source |
| P 0164 | MPRO_REF_SEL_MAN | Motion profile selection | Target reference source |
| P 0165 | MPRO_REF_SEL | Motion profile selction | Reference source |
| P 0300 | CON_CfgCon | Select control mode | Control mode must not be changed |

When a digital input set to "MAN(14)" is activated, the control location **P 0159 MPRO_REF_SEL switches to "TERM"** (switch to TERM is not displayed in the DM5). In parallel, the reference source is set to the reference selected via parameter **P 0164-MPRO_REF_SEL_MAN**. Additionally, the start signal must be connected to a digital input (ISDxx = Start).

The control mode **P 0300_CON_CfgCon** cannot be switched.
"MAN(14)" mode is displayed in the remote bit in the CIA 402.

Note:

- It is not possible to switch to "MAN" mode when the power stage is activated (system states 1,2,3) or when the drive in the DM5 is operated via the Control window.
- A level-triggered START (**P 0144 MPRO_DRVCOM_AUTO_START=LEVEL (1)**) is ignored in "MAN" mode. After activation of "MAN" mode, the START input must be reset.
- When "MAN" mode is ended the motor control also stops.

## 6.2 Digital outputs

The digital standard outputs OSD00 to OSD02 can also be assigned corresponding functions via selectors **P 0122** to **P 0124**. The relay output **P 0125 MPRO RELOUT1** is intended for the motor brake. It can also be assigned other functions via function selectors **P 0122 to P 0124** as necessary.

The digital output RELOUT2 is set to the "STO SH_H" function and its setting cannot be changed. Additional information on the STO function can be found in the "Safety" section of the Operation Manual.

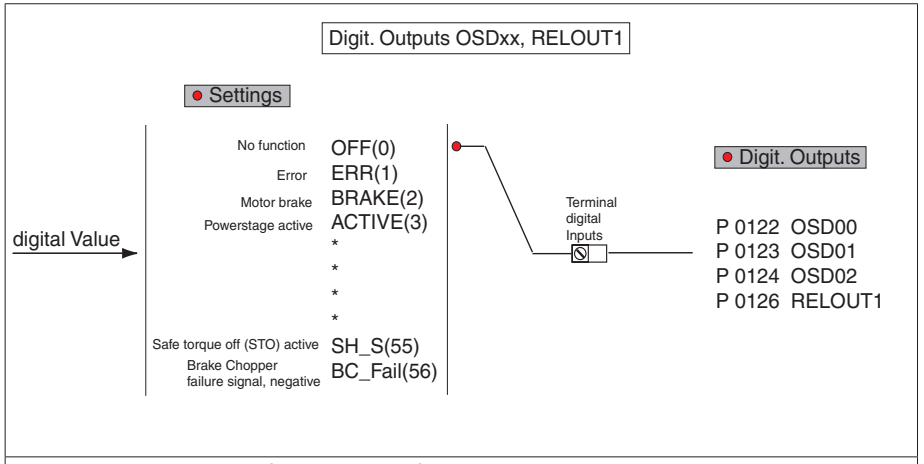



*Figure 6.5 Function block for adaptation of the digital outputs*

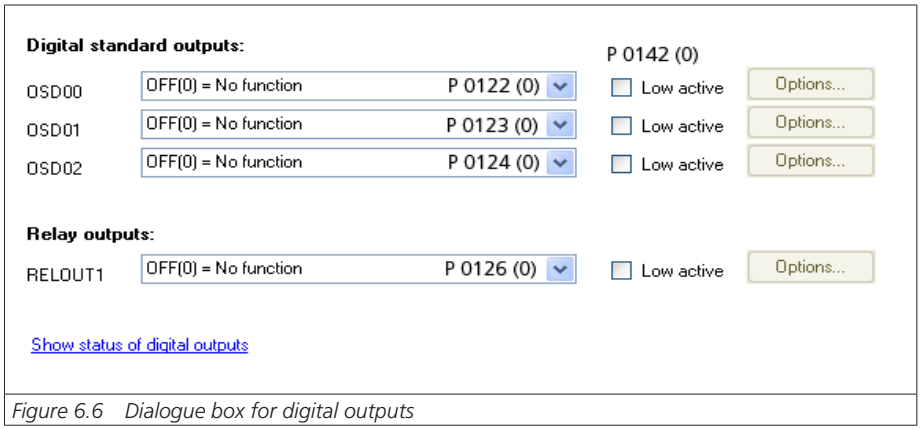



*Figure 6.6 Dialogue box for digital outputs*

| P.no. | Parameter name/Settings | Designation in DM 5 | Description |
|---|---|---|---|
| P 0122 - P 0127 | MPRO_OUTPUT_ FS_OSD0x | Function of digital output | Function selection |
| (0) | OFF(0) | No function | Input off |
| (1) | ERR(1) | Error | Collective error message |
| (2) | BRAKE(2) | Motor brake | Output becomes active in accordance with the holding brake function, see section 4.6, Motor brake. |
| (3) | ACTV(3) | Power activ | Power stage active and closed-loop/open-loop control in function |
| (4) | S_RDY(4) | Device initialized | Output is activated when the device is initialized after power-on. |
| (5) | C_RDY(5) | Control initialized | Output is activated when the device is "Ready to switch on" based on setting of the ENPO signal and no error message has occurred. Device ready - ReadyToSwitchOn flag in DriveCom status word set (in states 3, 4, 5, 6, 7) |
| *Warnings/warning thresholds are set via* **P 0730 MON_WarningLevel**. | | | |

| P.no. | Parameter name/Settings | Designation in DM 5 | Description |
|---|---|---|---|
| P 0122 - P 0127 | MPRO_OUTPUT_ FS_OSD0x | Function of digital output | Function selection |
| (6) | REF | Target reached, | The preset reference has been reached (depen-dent on control mode) |
| (7) | HOMATD | Homing attained | Homing complete |
| (8) | E_FLW | Following error | Tracking error |
| (9) | ROT_R | Rotation right | Motor in standstill window when running clockwise |
| (10) | ROT_L | Rotation left | Motor in standstill window when running anti-clockwise |
| (11) | ROT_0 | Motor stand still | Motor in standstill window, depending on actual value |
| (12) | STOP | Drive in "Quickstop" | The drive is in the "quick-stop" state |
| (13) | HALT | Drive in "halt" | Indicates system is in HALT state (activated via DS 402 profile, input or PROFIBUS IntermediateStop, SERCOS from V 2.0). Reaction according to HALT option code (P-2221 MPRO_402_HaltOC). |
| (14) | LIMIT | Reference limitation | The output function LIMIT(14) detects when a reference reaches its limitation. In this case the output is set. |
| (15) | N_GT_Nx | Speed greater than Nx | Nact greater than Nx where Nx = value in **P 0740 MON_SpeedThresh** |
| (16) | N_LT_Nx | Speed less than Nx | Nact less than Nx where Nx = value in **P 0740 MON_SpeedThresh** |
| (17) | P_LIM_activ | Position setpoint limited | Position reference limited (e.g. with parameter-ized software limit switches from V 2.0) |
| (18) | N_LIM_activ | Speed setpoint limited | Speed reference limitation active |
| (19) | I_LIM_activ | Current setpoint limited | Current reference active. |
| *Warnings/warning thresholds are set via* **P 0730 MON_WarningLevel**. | | | |

| P.no. | Parameter name/Settings | Designation in DM 5 | Description |
|---|---|---|---|
| P 0122 - P 0127 | MPRO_OUTPUT_ FS_OSD0x | Function of digital output | Function selection |
| (20) | COM | Set via communication profile | Set output via COM option (from V 2.0) |
| (21) | ENMO | Motor contactor output | Activate motor contactor (wiring of motor via contactor) |
| (22) | PLC | PLC sets output | Use output via PLC program |
| (23) | WARN | Warning | Collective warning message |
| (24) | UV | Warning undervoltage | Warning: undervoltage in DC link |
| (25) | WOW | Warning overvoltage | Warning: voltage overload in DC link |
| (26) | WIT | Warning IxIxt power stage | Warning $I^2xt$ power stage protection threshold reached |
| (27) | WOTM | Warning overtemperatur motor | Warning: motor temperature |
| (28) | WOTI | Warning overtemperatur drive | Warning heat sink temperature of inverter |
| (29) | WOTD | Warning overtemperatur motor | Warning internal temperature in inverter |
| (30) | WLIS | Warning current threshold reaktion | Warning apparent current limit value exceeded |
| (31) | WLS | Warning speed threshold reaktion | Warning speed limit value exceeded |
| (32) | WIT | Warning IxIxt motor protection | Warning $I^2xt$ motor protection threshold |
| (33) | WLTQ | Warning torque/force threshold | Warning torque limit value exceeded |
| (34) | TBACT | Table positioning active | Table positioning in AUTO and activated state |
| (35) | TB0 | Actual table index 2^0 | Significance $2^0$ |
| *Warnings/warning thresholds are set via* **P 0730 MON_WarningLevel**. | | | |

| P.no. | Parameter name/Settings | Designation in DM 5 | Description |
|---|---|---|---|
| P 0122 - P 0127 | MPRO_OUTPUT_ FS_OSD0x | Function of digital output | Function selection |
| (36) | TB1 | Actual table index 2^1 | Significance $2^1$ |
| (37) | TB2 | Actual table index 2^2 | Significance $2^2$ |
| (38) | TB3 | Actual table index 2^3 | Significance $2^3$ |
| (39)-(54) | CM1 – CM16 | Cam switch 1 bis 16 | Cam gear (as from V 2.0) |
| (55) | SH_S | Safe Standstill activ | STO function activated |
| (56) | BC:Fail | Brake chopper failure signet | Braking chopper error |
| *Warnings/warning thresholds are set via* **P 0730 MON_WarningLevel**. | | | |

## Output function "Reference reached REF(6)"

**P 0122 to P 0127 OSDxx = REF(6)**

For torque and speed control as well as positioning the setting REF(6) can be used to define a range in which the actual value may deviate from the reference without the "Reference reached" (REF) message becoming inactive. Reference fluctuations caused by reference input, e.g. via analog inputs, can thus be taken into account.

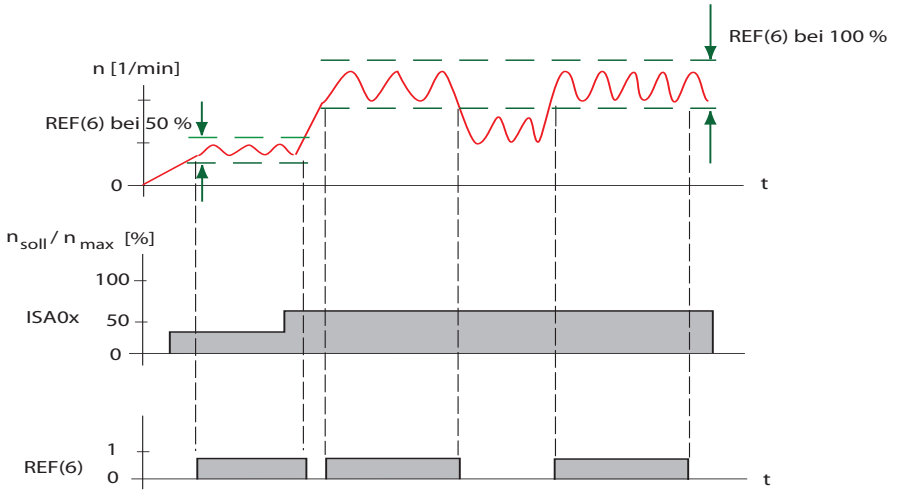



*Figure 6.7 REF setting: "Reference reached" window for speed control via analog input*

## Output function "LIMIT(14)"

The output function LIMIT(14) detects when a reference reaches its limit. In this case the output is set.

The limit values for maximum torque and maximum speed depend on the control mode. A detailed description is given in the Limits section.

**Torque control:**
Limit value monitoring becomes active when the torque reference exceeds the max. torque.

**Speed control:**
Limit value monitoring becomes active when the speed reference exceeds the max. speed.

**Positioning:**
Limit value monitoring becomes active when the speed reference exceeds the max. speed or the torque reference exceeds the max. torque.

**Endless positioning/speed mode:**

Monitoring is activated in endless positioning (speed mode) when the speed reference has been reached.

If an ongoing positioning operation is interrupted with "HALT", the "Reference reached" message is not sent in this phase. The message only appears after the actual target position has been reached.

## Output function "Switch motor contactor" OSDxx = ENMO(21)

The motor cable must always be switched with the power cut, otherwise problems such as burnt-out contactor contacts, overvoltage or overcurrent shut-off may occur.

In order to assure currentless switching, the contacts of the motor contactor must be closed before the power stage is enabled. In the opposite case the contacts must remain closed until the power stage has been switched off. This can be achieved by implementing the corresponding safety periods for switching of the motor contactor into the control sequence of the machine or by using the special ENMO software function of the drive controller.

A power contactor in the motor supply line can be directly controlled by the drive controller via parameter **P 0125 MPRO_OUTPUT_FS_MOTO = ENMO**. With the timer parameter **P 0148 MPRO_DRVCOM_ENMO_Ti** the on-and-off delay of the power contactor can be taken into account. This ensures that the reference will only be applied after the start enable when the contactor is closed, or if the motor is isolated from the position controller via contactor when the power stage is inactive.

Note: The **MPRO_DRVCOM_ENMO_Ti** timer time should allow additional times for typical contactor bounce. They may be several hundred ms, depending on contactor.

## Relay output RELOUT1/Motor brake:

This output is to be used in conjunction with a brake. If the output is set to BRAKE(2), the brake can be configured by way of the option field.

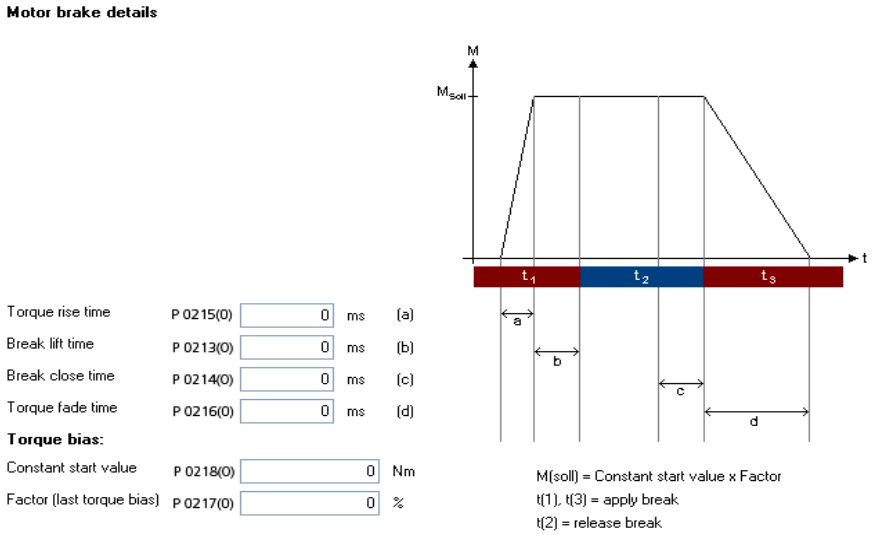



*Figure 6.8 Brake output*

An optional holding brake built-in to motor provides protection against unwanted motion when the power is cut and in case of error. If the brake is mounted on the axle mechanism and not directly on the shaft, undesirably severe torsional forces may occur on sudden engagement of the brake.

Attention: Please check the settings of the stop ramps if use of a holding brake is specified (Motion profile section, Stop ramps **P 2219**).

The brake response can be adapted to the requirements of the application as shown in the following illustration and using the parameters listed. This function can be used in both speed and position control mode.

## Brake function

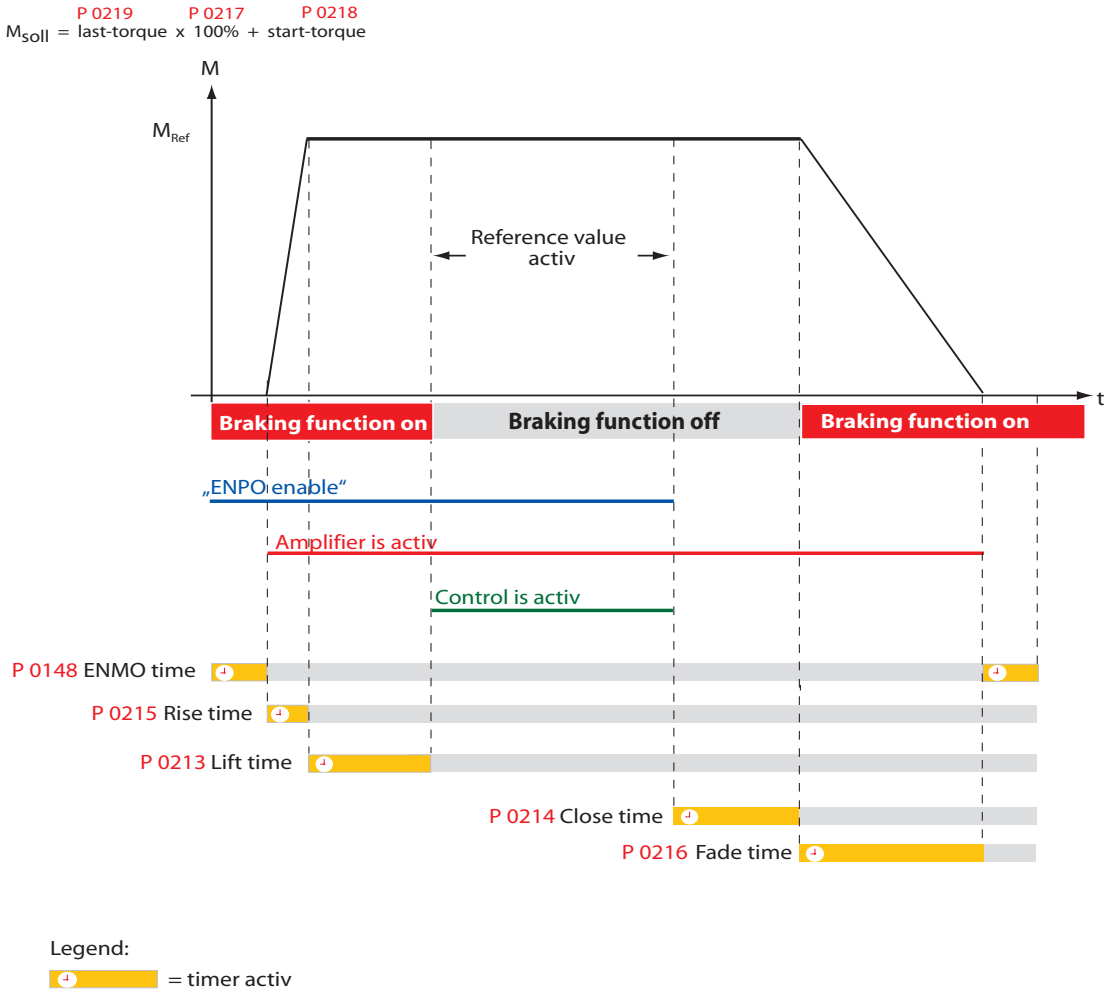



*Figure 6.9 Brake function graph*

| P. no. | Parameter name/Settings | Designation in DM 5 | Function |
|---|---|---|---|
| P 0125 | MPRO_OUTPUT_FS_MOTO | Setting of analog output from OFF(0) to BC_Fail(56) | Output for use of a motor holding brake. If no brake is used, the output can be used for a wide variety of other functions (section 6.2). |
| P 0147 | MPRO_DRVCOM_EPCHK | CHeck EnablePower | Power-up condition |
| (0) | OFF | Check enable power False for ENPO over ENMO | Hardware enable "ENPO" is switched via the motor contactor. |
| (1) | ON | Check enable power | ENPO must be switched via a digital input. |
| P 0148 | MPRO_DRVCOM_ENMO | Time out in "Ready/to switch On;" to enable motor switch | The timer "ENMO" (Enable Motor Contactor) generates an On/Off delay of the motor contactor and thus of the power stage. The effect is active when setting and resetting the START command and in case of error. |
| P 0213 | MPRO_BRK_LiftTime | Motor brake lift time | The "lift time" takes account of the mechanically dictated opening time of the brake. An applied reference will only be activated when this timer has elapsed. |
| P 0214 | MPRO_CloseTime | Motor brake close time | The "Closetime" starts after cancelling the start condition or in case of error. It is the mechanically dictated time which a brake takes to close. |
| P 0215 | MPRO_RiseTime | Motor brake torque rise time | The "rise time" is the rise of the ramp to build up the reference torque "Mref". |
| P 0216 | MPRO_FadeTime | Motor brake torque fade time | The "fade time" is the descending ramp to reduce the reference torque Mref to 0. |

| P. no. | Parameter name/Settings | Designation in DM 5 | Function |
|---|---|---|---|
| P 0217 | MPRO_BRK_Last-TorqFact: | Motor brake factor for application of last torque | If the loads change on restarting, a restart with the LastTorque (torque on shutdown) is recommended. In this case the actual value parameter is applied with a factor 1-100 %. (0 % = off). Note: On the very first power-up a Start-Torque P 0218 must be set. |
| P 0218 | MPRO_BRK_Start-Torq | Motor brake contstant initial torque | If the moving load always remains constant, Mref is set by way of parameter P 0218 "StartTorque". $M_{ref}$ = lasttorque * lasttorque-factor+ starttorque If LastTorque factor is set = 0 as per the formula, only the StartTorque setting is used. If StartTorque = 0 is set, the Last Torque is also used. On the very first operation there is no LastTorque though. In this case StartTorque is set = 0 and LastTorque factor unequal to 0 and then the control is started. The last torque applied is adopted. |
| P 0219 | MPRO_BRK_Last-Torq | Motor brake torque samples at last closing time | This parameter is only a display parameter. In it, the last torque applied is entered on shutdown and the scale factor P 0217 is applied to it as a percentage where necessary. |
| P 0220 | MPRO_BRK Lock | Lock brake | For testing only. By setting this parameter the brake can be applied during operation. |

## 6.3 Analog inputs

With the two analog inputs ISA00 and ISA01 the analog references (input signals) are processed and filtered. Four analog functions are available.

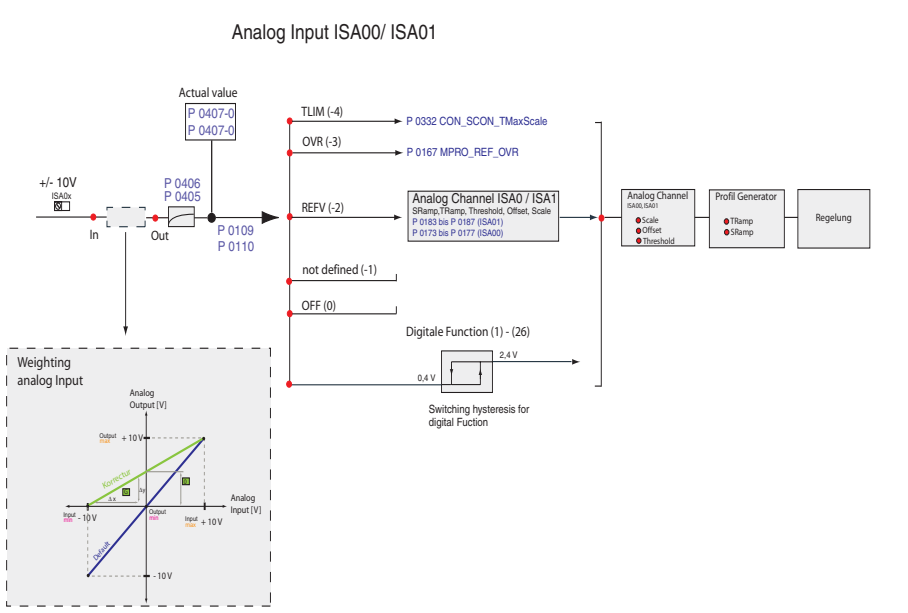



*Figure 6.10 Analog inputs function block, PG/IP switching, Analog channel and Weighting*

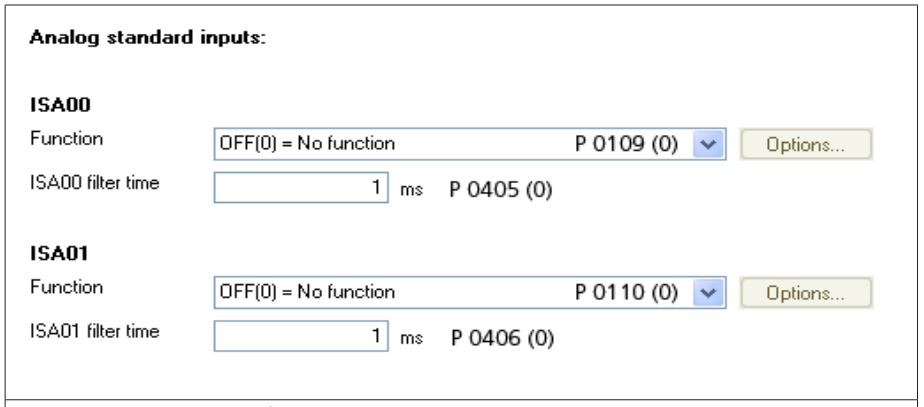



*Figure 6.11 Dialogue box for analog inputs*

### Analog setting options ((-4) to (-1))

| P.no. | Parameter name/ Settings | Designation in DM 5 | Function |
|---|---|---|---|
| P 0109<br>P 0110 | MPRO_INPUT_FS_ ISA00/ISA01 | Function of anlalog input ISA0x | Function selection |
| (-4) | TLIM(-4) | Analog Torque limit 0-100% | Online torque scaling: 0 to 10 V corresponds to 0-100 % of the maximum set torque. The torque scaling is recorded directly after the analog filter and before the backlash (threshold, offset). The analog input describes the parameter P 0332 SCON TMaxScale torque limitation. The backlash is therefore not effective for these functions. |
| (-3) | OVR(-3) | Speed Overrite 0-100% at positioning | 0 to 10 V corresponds to 0 – 100 % scaling of the parameterized travel speed in positioning. The override is tapped directly after the analog filter and before the backlash. At this point the system branches off to parameter **P 0167 Profile Speed override factor**. The backlash (threshold, offset) is thus without any effect for these functions! |

| P.no. | Parameter name/ Settings | Designation in DM 5 | Function |
|---|---|---|---|
| P 0109<br>P 0110 | MPRO_INPUT_FS_<br>ISA00/ISA01 | Function of anlalog input ISA0x | Function selection |
| (-2) | RERFV(-2) | Analog command | Reference input +/-10 V. Observe the scaling and adapt the reference structure by means of the reference selector. |
| (-1) | Not defined(-1) | Not defined | Not assigned |
| (0) | OFF(0) | No function | No function |
| (1)-(26) | START - Tab3<br>(1) - (26) | Corresponds to the settings for digital inputs ISD00 to ISD06 | The analog inputs ISD00 to ISD06 can also be used as digital inputs. |

Attention: The analog inputs are operated in a 1 ms cycle. By switching parameter **P 0301** from PG(0) to IP(1) mode, an analog input can be used as a "fast input". The switching frequency set in parameter **P 0305** for the interpolation takes effect

Note: The two analog inputs ISA00 and ISA01 can also be used as digital inputs (function (1) – (26)). The switching thresholds for reliable High Level and Low Level are:

high: > 2.4 V, Low: < 0.4 V

## 6.3.1 Weighting of analog inputs

It is possible to change the weighting of the two inputs. With the two parameters P 0428 and P 0439 the input gain and input offset can be changed.

Reasons for changing the weighting:

- Change to input voltage range of analog torque scaling
- Change to input voltage range of speed override function
- Change to switching threshold of a digital input function

The illustration shows how the weighting function works. With the specified formulas, the gain and offset can be defined.

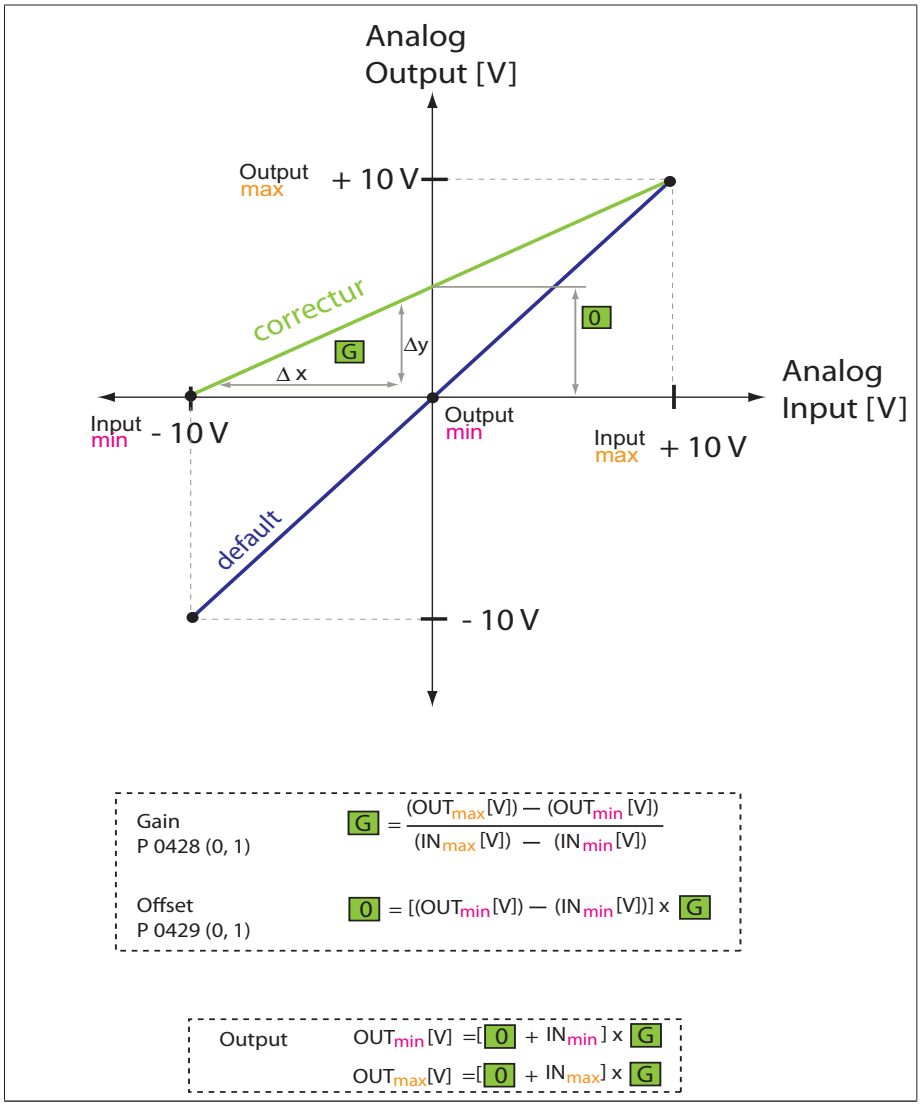



*Figure 6.12 Weighting of analog inputs*

Note: The output voltage of the weighting is not exactly limited to +/- 10 V.

**Example: Analog torque weighting:**

Default setting (standard controller function):
An input voltage range of the torque scaling from
0 V to +10 V corresponds to 0% - 100%.
-10 V to 0 V corresponds to 0%.

Correction of input and offset gain:
The entire +/-10 V input voltage range is to be used.

-10 V corresponds to 0%
+10 V corresponds to 100% of the torque scaling

The following settings are required for this:

-10 V input voltage ($In_{min}$ = -10 V) corresponds to 0 V output voltage ($Out_{min}$ = 0 V) corresponds to 0% torque scaling

+10 V input voltage (Inmax = +10 V) corresponds to +10 V output voltage (OUTmax = 0 V) corresponds to 100% torque scaling

Based on the formula, this results in:

| | |
|---|---|
| Gain | G = 0,5 |
| Offset | O = 5 V |

## 6.4 Analog output (option module)

The analog outputs serve to output an actual value from the device. To set the analog outputs OSA00 and OSA01 the scaled actual values to be outputted by the analog output must be specified.

The sampling time depends on the speed controller and is 125 µs (default). The following settings are available for processing of actual values:

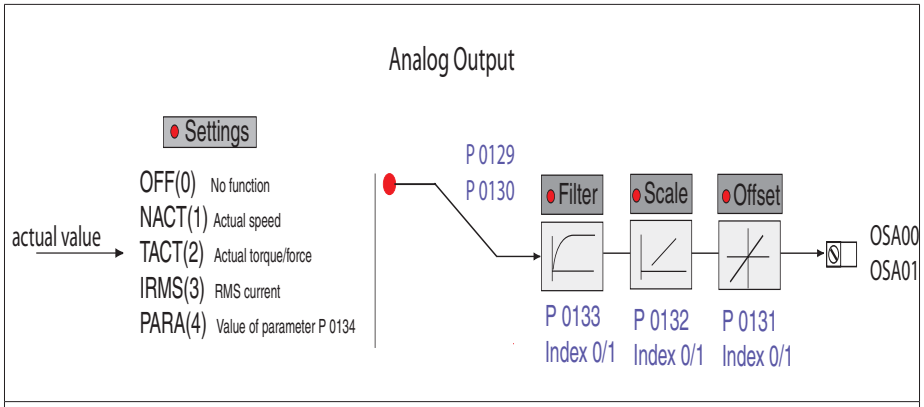



*Figure 6.13 Schematic of analog output with Filter, Scale, Offset functions*

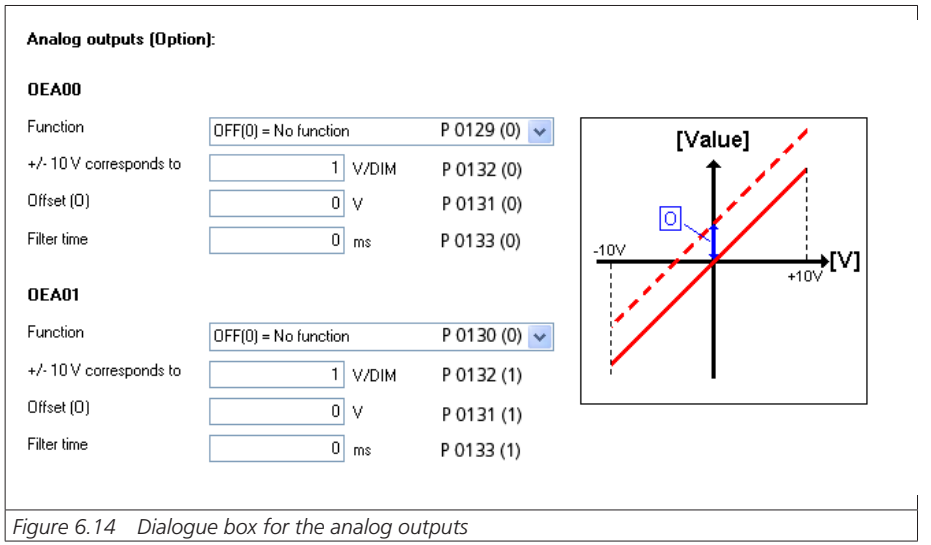



*Figure 6.14 Dialogue box for the analog outputs*

Analog output settings:

| P. no. | Parameter name/ Settings | Designation in DM 5 | Function |
|---|---|---|---|
| P 0129<br>P 0130 | MPRO_Output_FS_ OSA0/1 | Function of anlalog output OSAx | Function selection |
| (0) | OFF (0) | No function | No function |
| (1) | NACT(1) | Actual speed | Actual speed value |
| (2) | TACT(2) | Actual torque/force | Actual torque value |
| (3) | IRMS(3) | RMS current | Mean current value |
| (4) | PARA(4) | Value of parameter P 0134 | Value in parameter P 0134 is delivered directly at the analog output. |

| P. no. | Parameter name/ Settings | Designation in DM 5 | Function |
|---|---|---|---|
| P 0131 | **MPRO_Output_ OSAx_Offset** | MPRO_OUTPUT_OSA_Off-set | Offset |
| (0) | Offset | Offset OSA00 | Voltage offset in [V]:<br>Offset setting: Changing P 0131 shifts the operating point of the analog outputs out of the 0 point (see diagram above). |
| (1) | Offset | Offset OSA01 | |
| P 0132 | **MPRO_Output_ OSA0_Scale** | MPRO_OUTPUT_OSA_Scale | Scale |
| (0) | Scale | Scale OSA00 | Scaling of analog output:<br>Scale function setting: The scaling function can be used to scale the analog output. |
| (1) | Scale | Scale OSA01 | |
| P 0133 | **MPRO_Output_ OSA0_Filter** | MPRO_OUTPUT_OSA_Filter | Filter |
| (0) | filter | Filtertime for_OSA0 | Filter time of analog output:<br>Filter function setting: Noise and component spread can be compensated. |
| (1) | filter | Filtertime for_OSA1 | |

## 6.5 Motor brake

See “Digital outputs” section / Relay output RELOUT1.

# 7. Limits

## 7.1 Control limitation

To protect the device and the motor, it is necessary to limit some variables. The different limitations are described in the following. They take effect independently of other limitations within the motion profile. In addition, the servocontroller offers the possibility to set the limits for positive and negative values asymmetrically and/or to change the limits online. The limits are specified as percentages of the rated quantities (current, torque, speed,...), so that following calculation logical default settings are available. The default settings refer to 100% of the rated values and the parameters must thus be adapted to application and motor.

### 7.1.1 Torque limitation (torque/force limits)

To protect against overspeed, when the maximum rotation speed **P 0329** is reached a speed governor is activated which limits the speed to the configured maximum. It is possible to limit the negative (**P 0330**) and the positive torque (**P 0331**) independently of each other online.

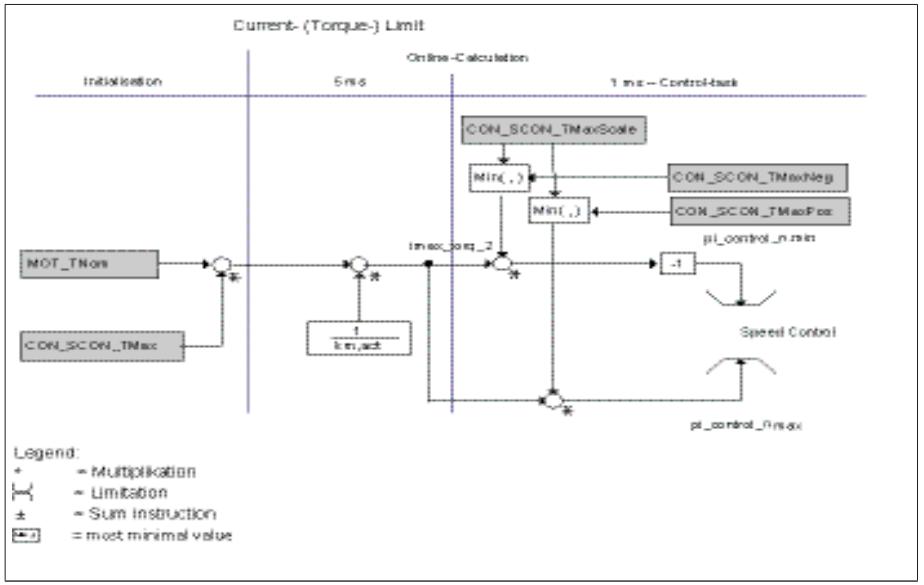



*Figure 7.12 Torque limitation without field-weakening*

Parameter:

| P. no. | Parameter name/ Settings | DM 5 designation | Function |
|---|---|---|---|
| P 0329 | CON_SCON_TMax | motor torque scaling of limits | Scaling of the maximum torque, referred to the rated torque **P 0460 MOT_TNom** (not changeable online). |
| P 0330 | CON_SCON_TMaxNeg | motor torque scaling of negative limit | Torque limitation in negative direction (not changeable online) |
| P 0331 | CON_SCON_TMaxPos | motor torque scaling of positive limit | Torque limitation in positive direction (not changeable online) |
| P 0332 | CON_SCON_TMax-Scale | motor torque scaling (online factor) | Percentage torque weighting (default 100%) (changeable online) |
| P 0460 | MOT_TNom | motor rated torque | Rated motor torque |
| P 0741 | MON_TorqueThres | monitoring torque/ force threshold | Setting of limit for torque threshold. |

The torque reference is limited symmetrically by parameter **P 0332**. If the limitation is to be directional, the setting can be made via **P 0330** (negative direction) and **P 0331** (positive direction). **The limitation of the torque reference always corresponds to the parameter with the lowest value.**

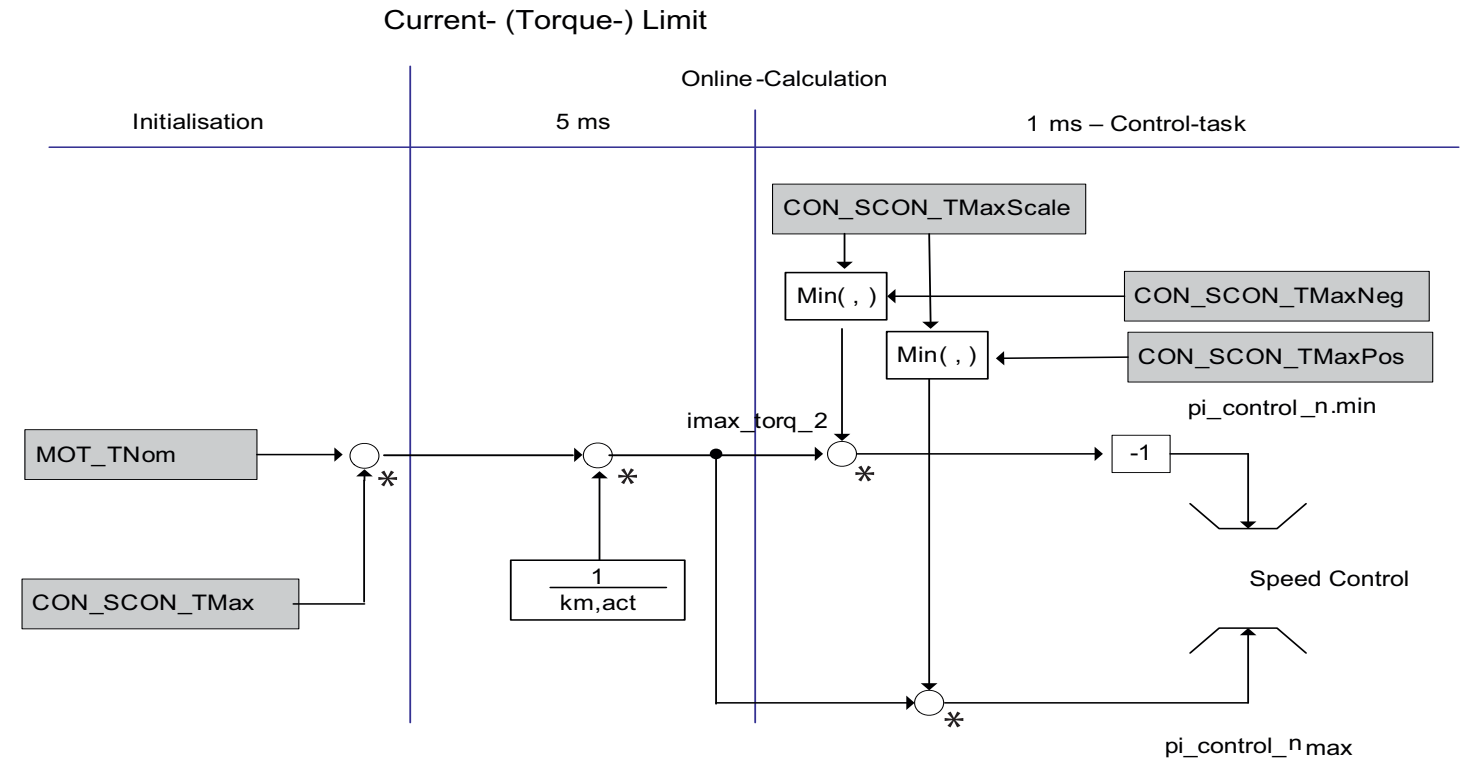



*Figure 7.13 Dependence in case of field-weakening and/or limitation by power stage*

In the following cases additional limitations of the torque may occur, so that the parameterized limit torque is not reached:

### Possible parameterization error:

Ratio of rated current to rated torque incorrect:
The torque constant of the motor (parameterized by way of the flux for a synchronous machine or the magnetizing current for an asynchronous machine) does not fit the ratio of rated current and rated torque. If the torque constant is less than this ratio, the motor current is limited in order to prevent excessively high motor current. These parameterization error is avoided by using an original motor data set or by generating the motor data using the servocontroller's calculation wizard.

Maximum power stage current too high:
The maximum current resulting from the torque limitation is greater than the maximum current of the power stage.

The field-forming d-current is not equal to zero:
In the field-weakening range the field-forming current isd becomes unequal to 0 for the synchronous machine. The q-current component $isq_{max}$ remaining for the torque is reduced correspondingly, so that the maximum current $is_{max}$ is not exceeded.

In the upper field-weakening range for asynchronous machines (the speed is then more than 3 to 5 times the rated speed) the slip is limited to the pull-out slip by reducing the torque limit.

## 7.1.2 Speed limitation Speed/Velocity

The following diagram shows the speed limitation structure. The speed can be symmetrically limited in relation to the rated speed by the scaling parameter **P 0328 CON_SCON_SMax**. Asymmetric limiting is possible via parameters **P 0333 CON_SCON_SMaxNeg** and **P 0334 CON_SCON_SMaxPos**.

An activated reversing lock (**P 0337 CON_SCON_DirLock**) also has an effect on the limitations with respect to the reference speeds for the control. The setting POS locks the positive references and NEG the negative references.

With **P 0745 MON_RefWindow** the standstill window is set for the speed.

Note: Parameters **P 0337 CON_SCON_SMaxScale**, **P 0328 CON_SCON_SMax** and **P 0335 CON_SCON_DirLock** are not changeable online. Parameters **P 0333 SCON_SCON_SMaxNeg**, **P 0334 CON_SCON_SMaxPos** are changeable online.

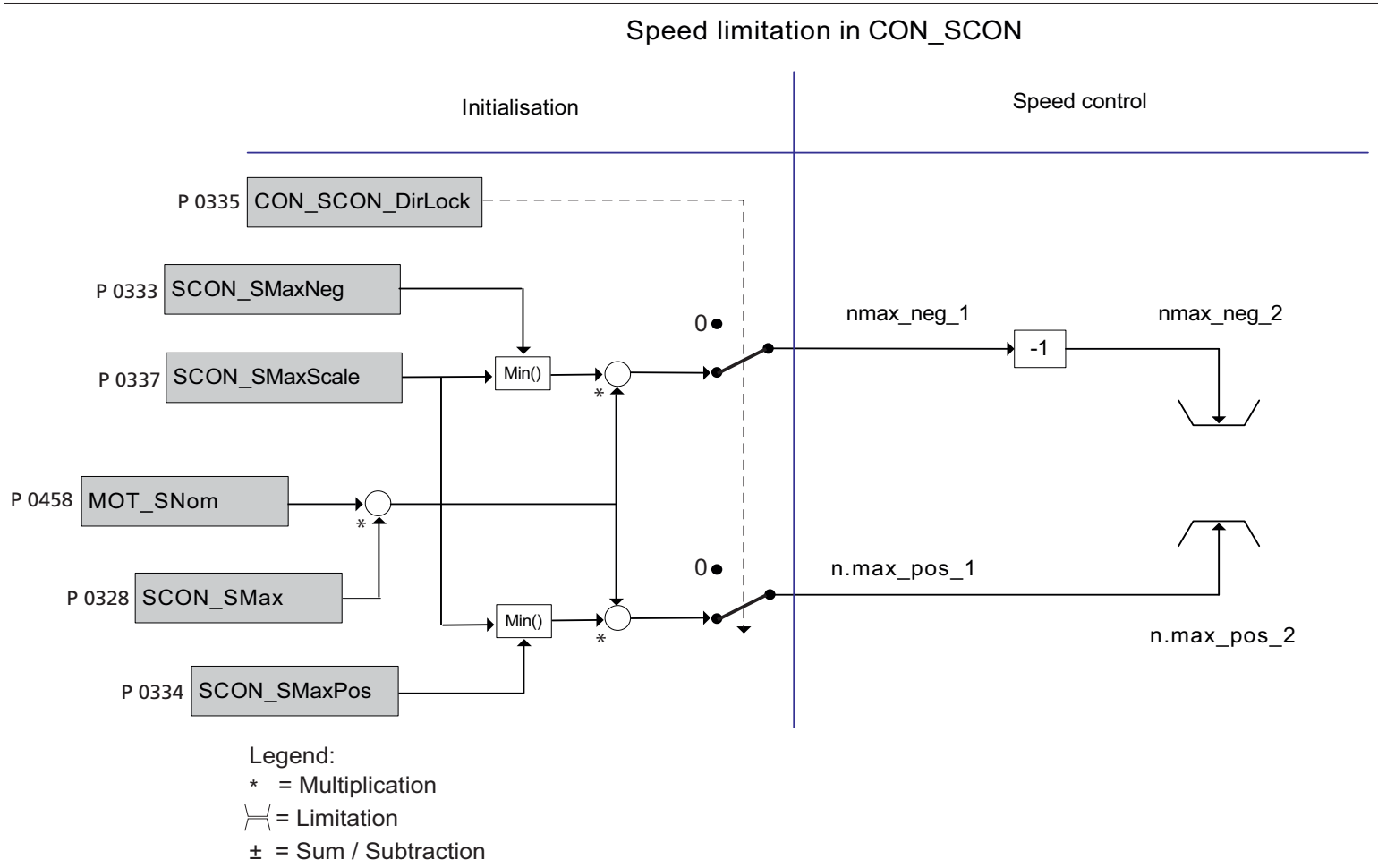



*Figure 7.14 Speed limitation*

Parameters:

| P-Nr. | Parameter name/ Settings | Designation in DM 5 | Function |
|---|---|---|---|
| P 0335 | CON_SCON_DirLock | Direction lock for speed reference value | Directional lock, left and right |
| P 0328 | CON_SCON_Max | Speed control maximum speed | Scaling to the rated speed in **P 0458 Motor** rated speed |
| P 0333 | CON_SCON_AMax-Neg | Motor speed scaling of negative limit | Speed limitation in negative direction |
| P 0334 | CON_SCON_TMax-Scale | motor torque scaling (on-line factor) | Speed limitation in positive direction |
| P 0337 | CONSCON_SMaxScale | Motor speed scaling | Percentage speed weighting (default 100%) |
| P 0740 | MON_SpeedThresh | monitoring speed threshold | Setting of threshold for maximum speed |
| P 0744 | MON_SDiffMax | Monitoring speed difference threshold | Setting of threshold for maximum position tracking error |
| P 0167 | MPRO_REF_OVR | Motionprofile speed override factor | Setting of override factor |

## 7.1.3 Position limitation

| P. no. | Parameter name/ Settings | Designation in DM 5 | Function |
|---|---|---|---|
| P 0743 | MON_UsrPosDiffMax | monitoring position difference threshold | Limit value for the maximum permissible tracking error in USER units |
| P 0746 | **MON_UsrPosWindow** | position window, for "target reached" status | Standstill window for position reached |

## 7.1.4 Power stage voltage limitation

| P. no. | Parameter name/ Settings | Designation in DM 5 | Function |
|---|---|---|---|
| P 0747 | MON_PF_ONLimit | voltage limit for power fail reaction | Voltage threshold for power failure response |

### Limitation of rated motor current

Note: Information on motor temperature and current limitation is given in the Motor and Encoder sections ($I^2xt$).

## 7.1.5 Power failure reaction

If the value of the d.c. link voltage drops below the value set in parameter **P 0747 MON_PF_OnLimit**, the error ERR-34 "Power failure detected" is reported and the parameterized error reaction is triggered.

By parameterizing a quick stop as an error reaction with a sufficiently steep deceleration ramp, the d.c. link voltage can be maintained above the undervoltage threshold (power failure bridging). This reaction lasts until the drive has been braked to a low speed.

The default setting is 0 V (function disabled).

## 7.1.6 Software limit switches

The software limit switches are only applicable in positioning mode, and are only activated once homing has been completed successfully.

The software limit switches are deactivated with the setting = 0.

| P. no. | Parameter name/ Settings | Designation in DM 5 | Function |
|---|---|---|---|
| P 2235 | MPRO_402_Software-PosLimit | 607DH DS 402 Software Position Limit | Positive and negative software limit switch |
| (1) | Software Position Limit | min position lim | Negative limit switch |
| (2) | Software Position Limit | max position lim | Positive limit switch |

The response to reaching a SW limit switch depends on the preset error response (see parameter P 0030 Error reaction).

| Positioning mode | Response |
|---|---|
| Absolute | Before enabling an absolute motion task, a check is made whether the target is in the valid range – that is, within the software limit switches.<br>If the target is outside, no motion task is signalled and the programmed error response as per P 0030 is executed. |
| Relative | |
| Endless (speed controlled) | The drive travels until a software limit switch is detected. Then the programmed error response as per P 0030 is executed. |

# 8. Diagnostics

## 8.1 Error status/Warning status

Errors are shown on the drive controller display (for D1/2 display see Operation Manual) and in parallel in the DriveManager. When a new error occurs, the bottom window opens, indicating the error name, location and cause. In addition, the green rectangle in the "Drive Status" switches to red.

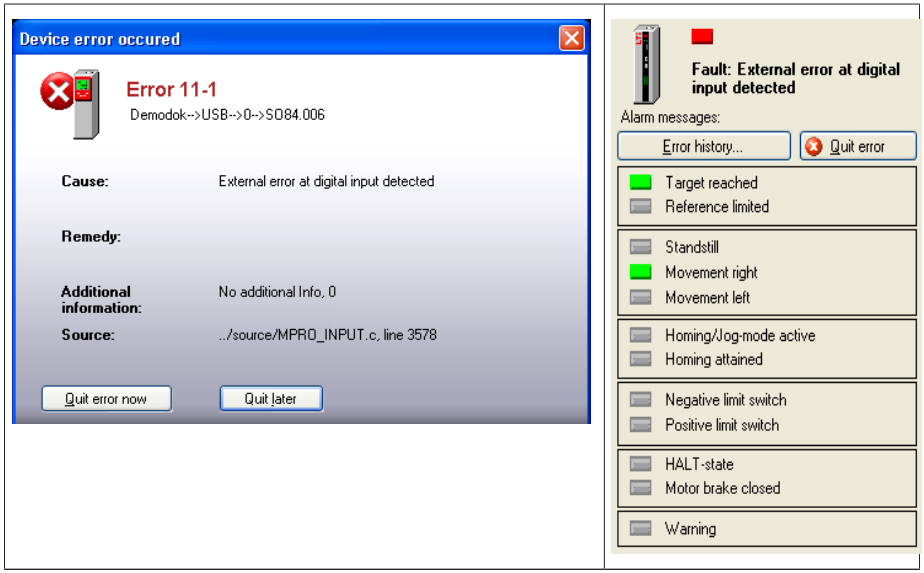



*Bild 8.1 Current error display*

Clicking the "Error" button in the "Drive Status" window calls up a buffer memory log listing the last 20 errors. When the 21st error occurs, the oldest error in the list is overwritten.

| No. | Label | Time stamp | Cause | Remedy |
|---|---|---|---|---|
| 1 | Error 11-1 | 2455760h | External error at digital input detected | |
| 2 | Error 18-8 | 2275817h | Homing/Jogging error: Drive not ready, wrong control m | Switch to supported control mode |
| 3 | Error 0-0 | 0h | | |
| 4 | Error 0-0 | 0h | | |

*Bild 8.2 Error history; storage of last 20 errors*

### 8.1.1 Error reactions

Each of the errors listed in parameter **P 0030** (Sub Id 0-44) can be assigned one of the error responses listed below.
However, not every error has every selection option.

| P. no. | Parameter name/ Settings | Description in DM 5 | Error reactions |
|---|---|---|---|
| P 0030 Sub Id 0-44 | Error Reactions | Programmable reaction in case of failure | Error response |
| (0) | Ignore | Ignore error | The error is ignored |
| (1) | Specific1 | Notify error, reaction is forced by internal PLC function block | A specific error response can be programmed via PLC |
| (2) | Specific2 | Notify error, reaction is forced by external control unit | A second specific error response can be programmed via PLC |
| (3) | FaultReaction OptionCode | Notify error, reaction as given by fault reaction option codes | The error is registered. The error reaction follows the set Error Option Code |

| P. no. | Parameter name/ Settings | Description in DM 5 | Error reactions |
|---|---|---|---|
| (4) | ServoStop | Notify error, execute quick stop and wait for restart of control | Quick stop, wait for control restart |
| (5) | ServoStopAndLock | Notify error, execute quick stop, disable power stage, protect against restart | Quick stop, block power stage, secure against switching on |
| (6) | ServoHalt | Notify error, disable power stage | Block power stage |
| (7) | ServoHaltAndLock | Notify error, block power stage, protect against restart | Block power stage, block enable |
| (8) | WaitERSAndReset | Notify error, block power stage and reset only via switching off/ on control voltage (24 V) | Block power stage, reset only by switching the 24 V control voltage off and back on |

## 8.1.2 Error details/Alarm & warning details

| P.no. P 0030 | Error name | Description of error |
|---|---|---|
| (0)) | **(0) no error** | No fault |
| (1) | (1) RunTimeError | Runtime error |
| | (2) RunTimeError_DynamicModules | Internal error in device initialization |
| | (3) RunTimeError_Flashmemomry | Error in flash initialization |
| | (4) RunTimeError_PLC | PLC runtime error |
| (2) | **ParaList** | |
| | (1) ParameterInit | Error in parameter initialization |
| | (2) ParameterVirginInit | Basic parameter initialization (factory setting) |
| | (3) ParameterSave | Parameter data backup |
| | (4) ParameterAdd | Registration of a parameter |
| | (5) ParameterCheck | Check of current parameter list values |
| | (6) ParameterListAdmin | Management of parameter list |
| | (7) ParaList_PST | Non-resettable errors from PowerStage: EEPROM data error |
| | (8) ParaList_PST_VL | Error in power stage initialization; selected device voltage not supported |
| (3) | **OFF** | |
| | (1) Off_MON_Device | Undervoltage |
| (4) | **OverVoltage** | |
| | (1) OverVoltage_MON_Device | Overvoltage |
| | | |
| (5) | **OverCurrent** | |
| | (1) OverCurrent_HardwareTrap | Overcurrent shut-off by hardware |
| | (2) OverCurrent_Soft | Overcurrent shut-off (fast) by software |
| | (3) OverCurrent_ADC | Measuring range of AD converter exceeded |
| | (4) OverCurrent_WireTest | Short-circuit test on initialization |
| | (5) OverCurrent_DC | (Fast) Overcurrent shut-off “below 5 Hz” |
| | (6) OverCurrent_Zero, | Total current monitoring |
| | (7) OverCurrent_I2TS | Fast I2xt at high overload |
| **(6)** | **OvertempMotor** | |
| | (1) OvertempMotor_MON_MotTemp | Calculated motor temperature above threshold value |
| | (2) OvertempMotor_MON_Device_DIN1 | PTC to DIN1 |
| | (3) OvertempMotor_MON_Device_DIN2 | PTC to DIN2 |

| P.no. P 0030 | Error name | Description of error |
|---|---|---|
| | (4) OvertempMotor_MON_Device_DIN3 | PTC to DIN3 |
| **(7)** | **OvertempInverter** | |
| | (1) OvertempInverter_MON_Device | Heat sink temperature too high |
| **(8)** | **OvertempDevice** | |
| | (1) OvertempDevice_MON_Device | Interior temperature evaluation |
| **(9)** | **I2tMotor** | |
| | (1) I²tMotor_MON_I2t | I²xt integrator has exceeded motor protection limit value (permissible current/time area) |
| **(10)** | **PowerAmplifier** | |
| | (1) I²tPowerAmplifier_MON_Device | I²xt power stage protection limit value exceeded |
| | | |
| **(11)** | **External** | |
| | (1) External_MPRO_INPUT | External error message |
| **(12)** | **CAN** | |
| | (1) ComOptCan_BusOff | CAN option: BusOff error |
| | (2) ComOptCan_Guarding | CAN option: Guarding error |
| | (3) ComOptCan_MsgTransmit | CAN option: Unable to send message |
| | (4) ComOptCan_HeartBeat | CAN option: Heartbeat error |
| | (5) ComOptCan_Addr | CAN option: Invalid address |
| | (6) ComOptCan_PdoMappingError | CAN option: Mapping error |
| | (7) ComOptCan_SyncTimeoutError | CAN option: Synchronization error |
| **(13)** | **SERCOS** | |
| | (1) ComOptSercos_HardwareInit | SERCOS: Hardware initialization |
| | (2) ComOptSercos_IllegalPhase | SERCOS: Invalid communication phase |

| P.no. P 0030 | Error name | Description of error |
|---|---|---|
| | (3) ComOptSercos_CableBreak | SERCOS: Cable break |
| | (4) ComOptSercos_DataDisturbed | SERCOS: Disturbed data transmission |
| | (5) ComOptSercos_MasterSync | SERCOS: Faulty synchronization |
| | (6) ComOptSercos_MasterData | SERCOS: Data telegrams missing |
| | (7) ComOptSercos_Address-Double | SERCOS: Duplicate address |
| | (8) ComOptSercos_Phase SwitchUp | SERCOS: Faulty phase switching (Up shift) |
| | (9) ComOptSercos_Phase SwitchDown | SERCOS: Faulty phase switching (Down shift) |
| | (10) ComOptSercos_Phase SwitchAck | SERCOS: Faulty phase switching (missing acknowledgement) |
| | (11) ComOptSercos_InitParaList | SERCOS: Faulty initialization of SERCOS parameter lists |
| | (12) ComOptSercos_ RunTimeError | SERCOS: Various runtime errors |
| | (13) ComOptSercos_Watchdog | SERCOS: Hardware watchdog |
| | (14) ComOptSercos_Para | SERCOS: Error in parameterization (selection of OP mode, IP times, etc...) |
| **(14)** | **EtherCat** | |
| | (1) ComOptEtherCat_Sm Watchdog0 | EtherCat: Sync-Manager0 - Watchdog |
| | (2) ComOptEtherCat_Wrong EepData | EtherCat: Parameter error, parameter data implausible |
| | (3) ComOptEtherCat_RamError | EtherCat: Internal RAM error |
| (15) | **Parameters** | |
| | (1) Parameter_MON_Device_ Current | Error in current monitoring initialization |
| | (2) Parameter_MON_I2t | Motor protection |

| P.no. P 0030 | Error name | Description of error |
|---|---|---|
| | (3) Parameter_CON_ICOM | Autocommutation: Plausibility tolerance exceeded |
| | (4) Parameter_CON_FM | Field model |
| | (5) Parameter_CON_Timing | Basic initialization of control |
| | (6) Parameter_MPRO_FG | Error calculating user units |
| | (7) Parameter_ENC_RATIO | Error initializing encoder gearing |
| | (8) Parameter_Nerf | Speed detection / observer |
| | (9) Parameter_ObsLib | Error in matrix library |
| | (10) Parameter_CON_CCON | Current control |
| | (11) Parameter_reserved1 | not used/reserved |
| | (12) Parameter_Inertia | Moment of inertia is zero |
| | (13) Parameter_MPRO | PARA_WatchDog in open-loop control via DM5 |
| | (14) Parameter_DV_INIT | DV_INIT: Error in system initialization |
| (16) | **SpeedDiff** | |
| | (1) SpeedDiff_MON_SDiff | Speed tracking error above threshold value |
| | (2) SpeedDiff_MON_NAct | Current speed above maximum speed of motor |
| (17) | **PositionDiff** | |
| | (1) PositionDiff_MON_ActDelta | Position tracking error too large |
| (18) | **Motion control** | |
| | (1) MotionControl_MC_HOMING_ LimitSwitchInterchanged | Homing: Limit switches interchanged |
| | (2) MotionControl:MC_HOMING: Unexpected home switch event | Homing: Limit switch tripped unexpectedly |
| | (3) MotionControl_MC_HOMING_ ErrorLimitSwitch | Homing: Limit switch error |
| | (4) MotionControl_MC_HOMING_ UnknownMethod | Homing: Wrong homing method, homing method not available |

| P.no. P 0030 | Error name | Description of error |
|---|---|---|
| | (5) MotionControl_MC_HOMING_ MethodUndefined | Homing: Homing method available but not defined |
| | (6) MotionControl_MC_HOMING_ DriveNotReadyHoming | Homing: Drive not ready for homing |
| | (7) MotionControl_MC_HOMING_ DriveNotReadyJogging | Homing: Drive not ready for jog mode |
| | (8) MotionControl_MC_HOMING_ WrongConMode | Homing: Control mode does not match homing method |
| | (9) MotionControl_MC_HOMING_ EncoderInitFailed | Homing: Encoder initialization error |
| | (10) MotionControl_MC_HOM-ING_MaxDistanceOverrun | Homing: Homing travel exceeded |
| | (11) MotionControl_MPRO_REF_En-abledOperationFailed | Max. permissible tracking error on “Start control” exceeded |
| | (12) MotionControl_MPRO_REF_SSP_ StackOverflow | Memory overflow for table values |
| | (13) MotionControl_MC_HOM-ING_RestoreBackupPos, | Error initializing last actual position after restart. |
| (19) | **FatalError** | Non-resettable error |
| | (1) FatalError_PowerStage_Limit_Idx | PST: Data index too large |
| | (2) FatalError_PowerStage_Switch-Freq | PST: Error in switching frequency-dependent data |
| | (3) FatalError_PowerStage_DataIn-valid | PST: Invalid EEPROM data |
| | (4) FatalError_PowerStage_CRC | PST: CRC error |
| | (5) FatalError_PowerStage_Error-ReadAccess | PST: Error reading power stage data |
| | (6) FatalError_PowerStage_Error-WriteAccess | PST: Error writing power stage data |
| | (7) FatalError_MON_Chopper | Current in braking resistor even though transistor switched off |

| P.no. P 0030 | Error name | Description of error |
|---|---|---|
| | (8) FatalError_HW_Identification | Hardware identification error |
| | (9) FatalError_FlashMemory | Error in flash memory |
| **(20)** | **HardwareLimitSwitch** | |
| | (1) HardwareLimitSwitch_Inter-changed | Limit switches swapped |
| | (2) HardwareLimitSwitch_LCW | Hardware limit switch LCW |
| | (3) HardwareLimitSwitch_LCCW | Hardware limit switch LCCW |
| **(21)** | **EncoderInit** | **Encoder general initialization (locations which cannot be assigned to a channel)** |
| | (1) EncoderInit_CON_ICOM_Eps Delta | Encoder general initialization: Autocommutation: excessive motion |
| | (2) EncoderInit_CON_ICOM_ Tolerance | Encoder general initialization: Autocommutation: excessive tolerance |
| **(22)** | **Encoder CH1Init** | **Encoder channel 1 initialization** |
| | (1) EncCH1Init_Sincos_Lines | Encoder channel 1 initialization, Sincos: Plausibility, lines from PRam_ENC_CH1_Lines |
| | (2) EncCH1Init_Sincos_ABSquareSum | Encoder channel 1 initialization, Sincos: Getting AB-SquareSum, Timeout |
| | (3) EncCH1Init_Sincos_EncObs | Encoder channel 1 initialization, SinCos: Encoder monitoring Sincos |
| | (4) EncCH1Init_EnDat2.1_ NoEnDat2.1 | Encoder channel 1 initialization, EnDat2.1: No EnDat2.1 encoder (encoder may be SSI) |
| | (5) EncCH1Init_EnDat2.1_Line5 | Encoder channel 1 initialization, EnDat2.1: Plausibility, lines from encoder |
| | (6) EncCH1Init_EnDat2.1_ Multiturn | Encoder channel 1 initialization, EnDat2.1: Plausibility “Multiturn” from encoder |
| | (7) EncCH1Init_EnDat2.1_ Singleturn | Encoder channel 1 initialization, EnDat2.1: Plausibility “Singleturn” from encoder |
| | (8) EncCH1Init_EnDat2.1_CrcPos | Encoder channel 1 initialization, EnDat2.1: CRC error position transfer |

| P.no. P 0030 | Error name | Description of error |
|---|---|---|
| | (9) EncCH1Init_EnDat2.1_ CrcData | Encoder channel 1 initialization, EnDat2.1: CRC error data transfer |
| | (10) EncCH1Init_EnDat2.1_ WriteToProt | Encoder channel 1 initialization, EnDat2.1: An attempt was made to write to the protection cells in the encoder! |
| | (11) EncCH1Init_EnDat2.1_ SscTimeout | Encoder channel 1 initialization, EnDat2.1: Timeout on SSC transfer |
| | (12) EncCH1Init_EnDat2.1_ StartbitTimeout | Encoder channel 1 initialization, EnDat2.1: Timeout, no start bit from encoder |
| | (13) EncCH1Init_EnDat2.1_ PosConvert | Encoder channel 1 initialization, EnDat2.1: Position data not consistent |
| | (14) EncCH1Init_SSI_Lines | Encoder channel 1 initialization, SSI: Plausibility “Lines” from encoder |
| | (15) EncCH1Init_SSI_Multiturn | Encoder channel 1 initialization, SSI: Plausibility “Multiturn” from encoder |
| | (16) EncCH1Init_SSI_Singleturn | Encoder channel 1 initialization, SSI: Plausibility “Singleturn” from encoder |
| | (17) EncCH1Init_SSI_ParityPos | Encoder channel 1 initialization, SSI: Parity error position transfer |
| | (18) EncCH1Init_SSI_SscTimeout | Encoder channel 1 initialization, SSI: Timeout on SSC transfer |
| | (19) EncCH1Init_SSI_PosConvert | Encoder channel 1 initialization, SSI: Position data not consistent |
| | (20) EncCH1Init_SSI_EncObs | Encoder channel 1 initialization, SSI: Encoder monitoring bit |
| | (21) EncCH1Init_Hiperface_ NoHiperface | Encoder channel 1 error initializing Hiperface interface |
| | (22) EncCH1Init_Hiperface_ Common | Encoder channel 1 initialization, Hiperface: Interface, general error |
| | (23) EncCH1Init_Hiperface_ Timeout | Encoder channel 1 initialization, Hiperface: Interface, Timeout |

| P.no. P 0030 | Error name | Description of error |
|---|---|---|
| | (24) EncCH1Init_Hiperface_ CommandMismatch | Encoder channel 1 initialization, Hiperface: Encoder, impossible COMMAND in response |
| | (25) EncCH1Init_Hiperface_ EStatResp_Crc | Encoder channel 1 initialization, Hiperface: CRC error in error status response |
| | (26) EncCH1Init_Hiperface_ EStatResp_Com | Encoder channel 1 initialization, Hiperface: Error status response returns communication error |
| | (27) EncCH1Init_Hiperface_ EStatResp_Tec | Encoder channel 1 initialization, Hiperface: Error status response returns technology or process error |
| | (28) EncCH1Init_Hiperface_ EStatResp_None | Encoder channel 1 initialization, Hiperface: Error status response returns no error(!) |
| | (29) EncCH1Init_Hiperface_ Response_Crc | Encoder channel 1 initialization, Hiperface: CRC error in response |
| | (30) EncCH1Init_Hiperface_ Response_Com | Encoder channel 1 initialization, Hiperface: Response with error bit: Status returns communication error |
| | (31) EncCH1Init_Hiperface_ Response_Tec | Encoder channel 1 initialization, Hiperface: Response with error bit: Status returns technology or process error |
| | (32) EncCH1Init_Hiperface_ Response_None | Encoder channel 1 initialization, Hiperface: Response with error bit: Status returns no error |
| | (33) EncCH1Init_Hiperface_ Status_Com | Encoder channel 1 initialization, Hiperface: Status telegram reports communication error |
| | (34) EncCH1Init_Hiperface_ Status_Tec | Encoder channel 1 initialization, Hiperface: Status telegram returns technology or process error |
| | (35) EncCH1Init_Hiperface_ TypeKey | Encoder channel 1 initialization, Hiperface: Type identification of encoder unknown |
| | (36) EncCH1Init_Hiperface_ WriteToProt | Encoder channel 1 initialization, Hiperface: An attempt was made to write to the protection cells in the encoder! |
| | (37) EncCH1Init_TTL_ IncompatibleHardware | Encoder channel 1 initialization, TTL: Control pcb does not support TTL evaluation |
| | (38) EncCH1Init_EnDat2.1_ PositionBits | Encoder channel 1 initialization, EnDat2.1: Plausibility “position bits” from encoder |
| | (39) EncCH1Init_EnDat2.1_ TransferBits | Encoder channel 1 initialization, EnDat2.1: Plausibility “transfer bits” in transfer |
| | (40) EncCH1Init_Np_ NominalIncrement | Encoder channel 1 initialization, NP: Plausibility “Lines” and “Nominal-Increment” |
| | (41) EncCh1Init_Endat21_Common | Encoder channel 1 initialization, Endat21: Interface general error |
| | (42) EncCh1Init_SSI_Common | Encoder channel 1 initialization, SSI: Interface general error |
| | (43) EncCh1Init_Sincos_Common | Encoder channel 1 initialization, Sincos: Interface general error |
| **(23)** | **EncChannel2Init** | |
| | (1) EncCH2Init_Res_Lines | Encoder channel 2 initialization, Res: Plausibility “lines” from PRam_ENC_CH2_Lines |
| | (2) EncCH2Init_Res_ ABSquareSum_TimeOut | Encoder channel 2 initialization, Res: Getting AB-Square-Sum, Timeout |
| | (3) EncCH2Init_Res_EncObs | Encoder channel 2 initialization, Res: Encoder monitoring resolver |
| **(24)** | **EncCH3Init** | |
| | (1) EncCH3Init_Module IdentificationFailed | Encoder channel 3 initialization: No module inserted or wrong module |
| | (2) EncCH3Init_Common_EO_ Error | Encoder channel 3 initialization: General EO error (encoder option) |
| | (3) EncCH3Init_SSI_EncObs_20c | Encoder channel 3 initialization: Encoder monitoring |
| | (4) EncCH3Init_EnDat2.1_ NoEnDat2.1 | Encoder channel 3 initialization, EnDat2.1: No EnDat2.1 encoder (encoder may be SSI) |
| | (5) EncCH3Init_EnDat2.1_Lines | Encoder channel 3 initialization, EnDat2.1: Plausibility “Lines” from encoder |
| | (6) EncCH3Init_EnDat2.1_ Multiturn | Encoder channel 3 initialization, EnDat2.1: Plausibility “Multiturn” from encoder |
| | (7) EncCH3Init_EnDat2.1_ Singleturn | Encoder channel 3 initialization, EnDat2.1: Plausibility “Singleturn” from encoder |

| P.no. P 0030 | Error name | Description of error |
|---|---|---|
| | (8) EncCH3Init_EnDat2.1_CrcPos | Encoder channel 3 initialization, EnDat2.1: CRC error position transfer |
| | (9) EncCH3Init_EnDat2.1_CrcData | Encoder channel 3 initialization, EnDat2.1: CRC error data transfer |
| | (10) EncCH3Init_EnDat2.1_ WriteToProt | Encoder channel 3 initialization, EnDat2.1: An attempt was made to write to the protection cells in the encoder! |
| | (11) EncCH3Init_EnDat2.1_ SscTimeout | Encoder channel 3 initialization, EnDat2.1: Timeout on SSC transfer |
| | (12) EncCH3Init_EnDat2.1_ StartbitTimeout | Encoder channel 3 initialization, EnDat2.1: Timeout, no start bit from encoder |
| | (13) EncCH3Init_EnDat2.1_ PosConvert | Encoder channel 3 initialization, EnDat2.1: Position data not consistent |
| | (14) EncCH3Init_SSI_Lines | Encoder channel 3 initialization, SSI: Error initializing SSI interface |
| | (15) EncCH3Init_SSI_Multiturn | Encoder channel 3 initialization, SSI: Plausibility "Multiturn" from encoder |
| | (16) EncCH3Init_SSI_Singleturn | Encoder channel 3 initialization, SSI: Plausibility "Singleturn" from encoder |
| | (17) EncCH3Init_SSI_ParityPos | Encoder channel 3 initialization, SSI: Parity error position transfer |
| | (18) EncCH3Init_SSI_SscTimeout | Encoder channel 3 initialization, SSI: Timeout on SSC transfer |
| | (19) EncCH3Init_SSI_PosConvert | Encoder channel 3 initialization, SSI: Position data not consistent |
| | (20) EncCH3Init_SSI_EncObs | Encoder channel 3 initialization, SSI: Encoder monitoring bit |
| | (38) EncCH3Init_EnDat2.1_ PositionBits | Encoder channel 3 initialization, EnDat2.1: Plausibility "position bits" from encoder |
| | (39) EncCH3Init_EnDat2.1_ TransferBits | Encoder channel 3 initialization, EnDat2.1: Plausibility "transfer bits" in transfer |

| P.no. P 0030 | Error name | Description of error |
|---|---|---|
| | (40) EncCH3Init_Np_ NominalIncrement | Encoder channel 3 initialization, NP: Plausibility "Lines" and "Nominal-Increment" |
| | (41) EncCH3Init_Endat21_Common | Encoder channel 3 initialization, EnDat21: Interface, general error |
| | (42) EncCH3Init_SSI_Common | Encoder channel 3 initialization, SSi: Interface, general error |
| | (43) EncCH3Init_Sincos_Common | Encoder channel 3 initialization, Sincos: Interface, general error |
| | (50) EncCH3Init_TOPT_cfg | Encoder channel 3 initialization, interface, general error |
| **(25)** | **EncoderCycl** | **Encoder general cyclic** |
| | (1) EncoderCycl_CON_ ICOM_Epsdelta | Encoder general cyclic: Autocommutation: excessive motion |
| | (2) EncoderCycl_CON_ ICOM_Tolerance | Encoder general cyclic: Autocommutation: excessive tolerance |
| **(26)** | **EncCh1Cycl** | |
| | (1) EncCH1Cycl_Np_Distance | Encoder channel 1 cyclic, NP: Plausibility, CounterDistance |
| | (2) EncCH1Cycl_Np_ DeltaCorrection | Encoder channel 1 cyclic, NP: Delta correction not possible |
| | (3) EncCH1Cycl_Np_Delta | Encoder channel 1 cyclic, NP: Plausibility "CounterDelta" |
| **(27)** | **EncCh2Cycl** | |
| | (1) EncCH2Cycl_NoLocation | Not used |
| **(28)** | **EncCh3Cycl** | |
| | (1) EncCH3Cycl_NoLocation | Not used |
| **(29)** | **TC (TriCore)** | |
| | (1) TC_ASC | TriCore ASC |
| | (2) TC_ASC2 | TriCore ASC2 |
| | (3) TC_FPU | TriCore floating point error |

| P.no. P 0030 | Error name | Description of error |
|---|---|---|
| | (4) TC_FPU_NO_RET_ADDR | riCore floating point error, no return address available |
| **(30)** | **InitCon** | |
| | (1) InitCon_AnaInput | Initialization error analog input |
| | (2) InitCon_FM_GetKM | Initialization error calculating motor torque constant |
| | (3) InitCon_FM_ASM | Initialization error asynchronous motor |
| | (4) InitCon_FM_ASM_FW | Initialization error asynchronous motor in field-weakening |
| **(31)** | **PLC** | |
| | (1) PLC_Location 0...65536 | User-specific: Errors generated in PLC program |
| **(32)** | **Profibus** | |
| | (1) ComOptDp_Timeout | PROFIBUS DP: Process data Timeout |
| **(33)** | **Timing** | **Task overflow** |
| | (1) Timing_ADCTask_ReEntry | ADC task automatically interrupted |
| | (2) Timin_ControlTask | Control task exceeded scan time |
| **(34)** | **PowerFail** | **Power failure detection** |
| | PowerFail | Power failure detection; supply voltage error |
| **(35)** | **EncObs** | **Encoder cable break** |
| | (1) EncObs_CH1_Sincos | Cable break: Encoder channel 1 |
| | (1) EncObs_CH2_Resolver | Cable break: Encoder channel 2 |
| | (1) EncObs_CH3_Sincos | Cable break: Encoder channel 3 |
| | (1) EncObs_CH1_SSI | Cable break: Encoder channel 1 |
| **(36)** | **VARAN** | |
| | (1) ComOptVARAN_InitHwError | Error in hardware initialization: VARAN option |
| | (2) ComOptVARAN_BusOffError | "Bus off" error; no bus communication: VARAN option |

| P.no. P 0030 | Error name | Description of error |
|---|---|---|
| **(37)** | **Syncronization controller** | |
| | (1) RatioError | The ratios between interpolation, synchronization and/or speed control time do not match |
| **(38)** | **Braking chopper monitoring** | |
| | (1) BC_Overload | Braking chopper overload |
| **(39)** | **TwinWindow** | **Monitoring of speed and torque** |
| | (1) TwinWindow_Speed | Speed deviation between Master and Slave |
| | (2) TwinWindow_Torque | Torque deviation between Master and Slave |
| **(40)** | **Twin-Sync-Module** | **Communication fault TECH option** |
| | (1) TOPT_TWIN_CommLost | Error in "Twin Sync" technology option |
| | (2) TOPT_TWIN_SwitchFreq | |
| | (3) TOPT_TWIN_ModeConflict | |
| | (4) TOPT_TWIN_RemoteError | |
| **(41)** | **DC link fast discharge** | **Maximum period for fast discharge** |
| | (1) FastDischarge_Timeout | Maximum period for fast discharge exceeded (35s) |
| **(42)** | **EtherCAT Master Implementation** | **Fehler EtherCat Master** |
| | (1) Location can't specified CommError | Communication error EtherCat Master |
| **(43)** | **Ethernet interface** | **Error in Ethernet configuration** |
| | (1) Ethernet_Init | Initialization error TCP/IP communication |
| **(44)** | **Cable break detected** | |
| | (1) WireBreak_MotorBrake | No consumer on output X13 (motor holding brake) |

### 8.1.3 Warning messages

In order to get timely information on excessive or inadequate values via an external controller or the drive's internal PLC, warning thresholds can be freely parameterized with **P 0730**. Each warning is assigned on and off thresholds. This enables parameterization of a hysteresis.

When a warning is triggered, the corresponding bit is entered in parameter **P 0034-ERR_WRN_State**. The binary value enables a status interrogation. Warnings can also be programmed onto digital outputs (see section 6, I/O's). The following warning thresholds are supported by the parameter:

| P 0034 | Warning thresholds |
|---|---|
| BIT number | |
| 0 | $I^2xt$ integrator (motor) warning threshold exceeded |
| 1 | Heat sink temperature |
| 2 | Motor temperature |
| 3 | Interior temperature |
| 4 | Reserved for SERCOS |
| 5 | Overspeed |
| 6 | Reserved for SERCOS |
| 7 | Reserved for SERCOS |
| 8 | Reserved for SERCOS |
| 9 | Undervoltage |
| 10 | Reserved for SERCOS |
| 11 | Reserved for SERCOS |
| 12 | Reserved for SERCOS |
| 13 | Reserved for SERCOS |
| 14 | Reserved for SERCOS |
| 15 | Reserved for SERCOS |
| 16 | I2xt integrator (device) exceeded |
| 17 | Monitoring of apparent current |
| 18 | Overvoltage |
| 19 | Protection of braking chopper, warning threshold exceeded |
| 20 | Overtorque |
| 21 | Reserve |
| 22 | Reserve |
| 23 | Reserve |
| 24 | Speed reference limitation active |
| 25 | Current reference limitation |
| 26 | Right limit switch active |
| 27 | Left limit switch active |
| 28 | External warning via input |
| 29 | Reserve |
| 30 | Reserve |
| 31 | Reserve |

The ON and OFF options enable suitable on and off thresholds (switching hysteresis) to be defined for the following warnings.

| P 0730 Index | Parameter name MON WarnigLevel | Meaning Warning level | Warnings |
|---|---|---|---|
| 0 | UnderVoltage_ON | DC link undervoltage | Undervoltage |
| 1 | UnderVoltage_OFF | DC link undervoltage | |
| 2 | OverVColtage_ON | DC link overvoltage | Overvoltage |
| 3 | OverVoltage_OFF | DC link overvoltage | |

| P 0730 Index | Parameter name MON WarnigLevel | Meaning Warning level | Warnings |
|---|---|---|---|
| 4 | Current_ON | Motor current | Motor current |
| 5 | Current_OFF | Motor current | |
| 6 | Device I2t_ON | I²t internal device protection | I²xt device protection |
| 7 | Device I2t_OFF | I²t internal device protection | |
| 8 | Motor I^2_ON | I²t Motor protection | I²xt motor protection |
| 9 | Motor I^2_OFF | I²t Motor protection | |
| 10 | Torque ON | Motor torque | Torque limit reached |
| 11 | Torque OFF | Motor torque | |
| 12 | Speed On | Motor actual speed | Speed limit reached |
| 13 | Speed OFF | Motor actual speed | |
| 14 | TC ON | Cooler (power electronics) temperature | Heat sink temperature reached |
| 15 | TC OFF | Cooler (power electronics) temperature | |
| 16 | Tint ON | Internal (control electronics) temperature | Housing internal temperature reached |
| 17 | Tint OFF | Internal (control electronics) temperature | |
| 18 | MotorTemp ON | Motor temperatur | Motor temperature reached |
| 19 | MotorTemp OFF | Motor temperatur | |

# 9. Field bus systems

## 9.1 CANopen

### CANopen functionality of the ServoOne

The CANopen Communication Profile is documented in the CiA DS-301, and regulates "how" communication is executed. It differentiates between Process Data Objects (PDOs) and Service Data Objects (SDOs). The communication profile additionally defines a simplified network management system.

Based on the communication services of DS-301 (Rev. 4.01) the device profile for variable-speed drives DSP402 was created. It describes the operation modes and device parameters supported.

Note: For a detailed description of the CANopen field bus system refer to the separate "CANopen User Manual".

## 9.2 PROFIBUS-DP

### Short description of ServoOne PROFIBUS DP interface

Reference to PROFIdrive specification

The implementation in the ServoOne is based on the PROFIdrive profile "PROFIBUS PROFdrive-Profile Version 4.0".

### Key features

- Data transmission using two-wire twisted pair cable (RS 485)
- Transfer rate: optionally 9.6 K, 19.2 K, 45.45 K, 93.75 K, 187.5 K, 500 K, 1.5 M, 3 M, 6 M or 12 MBaud
- Automatic baud rate detection
- PROFIBUS address can be set using the rotary coding switches or alternatively using the addressing parameters
- Cyclic data exchange reference and actual values using DPV0
- Acyclic data exchange using DPV1
- Synchronisation of all connected drives using freeze mode and sync mode
- Reading and writing drive parameters using the PKW channel or DPV1

Note: For a detailed description of the PROFIBUS field bus system refer to the separate "Profibus User Manual".

## 9.3 SERCOS

### Short description of ServoOne SERCOS interface

The basis for implementing SERCOS in the ServoOne is the document titled "Specification SERCOS Interface Version 2.2"

### Key features

- Data transfer by fibre-optic cable
- Transfer rate: optionally 2, 4, 8 or 16 MBaud
- Automatic baud rate detection
- Transmission power adjustable by DIP switches

– SERCOS address programmable via buttons and display
– Cyclic data exchange of references and actual values with exact time equidistance
– SERCOS sampling time of 125 µs to 65 ms (multiples of 125 µs programmable)
– Multi-axis synchronization between reference action times and actual value measurement times of all drives in the loop
– Full synchronization of all connected drives with the master control system

– Free configuration of telegram content
– Maximum configurable data volume in MDT: 20 bytes
– Maximum configurable data volume in AT: 20 bytes
– Programmable parameter weighting and polarity for position, velocity, acceleration and torque
– Modulo weighting
– Additive velocity and torque references
– Fine-interpolation (linear or cubic) inside the drive
– Optionally master control-side (external) or in-drive generation of rotation speed and acceleration pre-control
– Service channel for parameter setting and diagnosis
– Support for touch probes 1 and 2
– Support for configurable real-time status and control bits
– Support for configurable signal status and control word
– Supported commands:
– S-0-0099 Reset state class 1
– S-0-0127 Preparation for switch to phase 3
– S-0-0127 S-0-0128 Preparation for switch to phase 4
– S-0-0148 Drive-controlled homing
– S-0-0152 “Position spindle” command
– S-0-0170 “Touchprobe” command
– S-0-0262 “Parameter initialization to defaults“ command
– S-0-0263 “Parameter initialization to backup values“ command
– S-0-0264 “Save current parameter values” command

Note: For a detailed description of the SERCOS field bus system refer to the separate “SERCOS User Manual”.

# 10. Technology option

## 10.1 SinCos module

The SinCos module enables evaluation of high-resolution encoders. A track signal period is interpolated at a 12-bit resolution (fine interpolation).

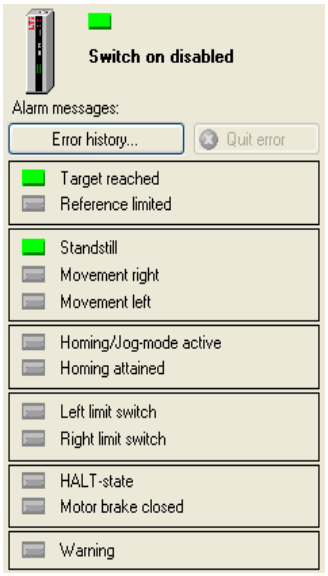
Evaluation of the absolute value information is in preparation.

Note: For more information refer to the “SinCos Module” specification.

# A Appendix

## Drive status

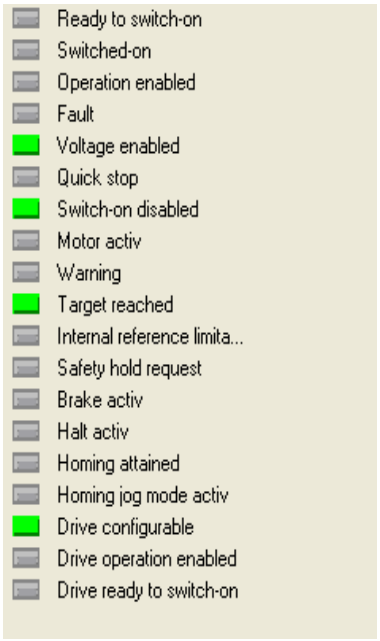
The “Drive status” window displays the current device status. In an error state the green rectangle at the top turns red. The rectangles at the bottom turn from transparent to green as soon as a condition (high) is met.




As soon as an error is detected, the status indicator at the top of the window turns red. Detailed information on the error and on previous errors can be viewed by clicking the “Error history” button. At the bottom of the window the current state are displayed. A green light signifies active.

*Figure A.1 Drive status window*

## Status bits




The “Status bits” window displays the current system states. The basis of those states is the DriveCom state machine. The active states are displayed in green. A schematic view is presented in figure A 3 and in figure 5.36 in the “Motion profile” section.

*Figure A.2 Status bits window*

## State machine

State machine of the drive controller:
The system states of the controller are recorded in the bordered boxes. Blue arrows designate the individual state transitions, oriented to CiA 402. Changeable state transitions are bordered in grey.

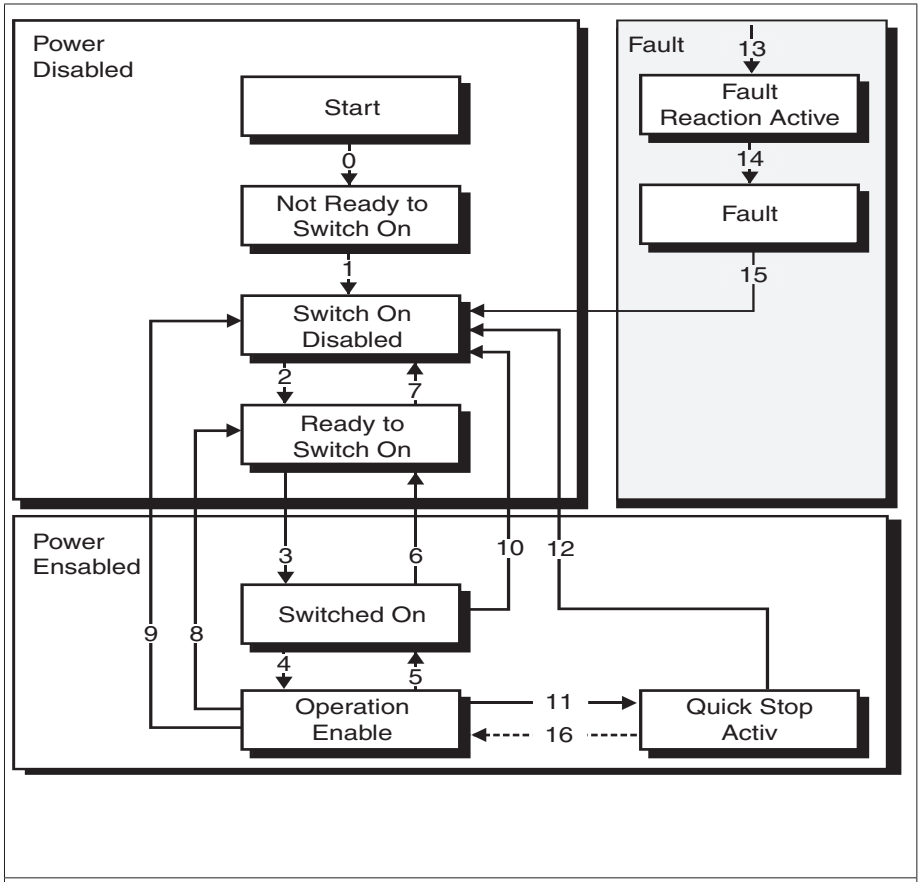



*Bild A.15 State machine of the drive controller*

## Manual mode

Manual mode enables a controller to be controlled in different modes regardless of whether a higher-level control system is pre-installed or not. All that is required is for the hardware to be enabled first (STO and ENPO).
**When the manual mode window is closed, all the original settings are restored.**
The drive motion can be plotted with the scope function, permitting analysis of the control performance for example.

ATTENTION: Before this function is started, a controller must have been commissioned into operation as stipulated in the Operation Manual. When the Control window is opened the parameter settings in the connected device are automatically changed and are then restored when the window is closed. Communication should not be interrupted (such as by a power failure, unplugging the connecting cable or suchlike) while the Control window is active.

DANGER: Manual mode causes the axis to execute movements. The connected control system is not active, and cannot intervene in the movement. It must be ensured that no hazard is posed to people or machinery.

In an emergency, the drive can be stopped at any time by cancelling the hardware enable (ENPO, STO). In the case of lifting applications, it must be ensured that a mechanical brake is installed.

Note: If a drive cannot be moved by way of the Control window, check the following points:

- Controller system state
- Motor data
- Possibly safety switch
- Quick stop active
- Hardware enable via STO and ENPO

Note: For a detailed description of **manual mode**, **the drive**, **administration** and **actual values**, and for information on **firmware downloading** refer to the separate "DriveManager User Manual".

# Monitoring functions

## Actual values

| P. no. | Parameter name/Setting | Designation in DM 5 | Function |
|---|---|---|---|
| P 0276 | MPRO_FG_UsrActPos | actual position in user units | Current position in user units |
| P 0277 | MPRO_FG_UsrRefPos | reference position in user units | Reference position in user units |
| P 0278 | MPRO_FG_UsrCmdPos | position command in user units | Position command in user units |
| P 0279 | MPRO_FG_UsrPosDiff | tracking error in user units | Tracking error in user units |
| P 0280 | MPRO_FG_UsrRefSpeed | reference speed in user units | Speed reference in user unit |
| P 0281 | MPRO_FG_UsrActSpeed | actual speed in user units | Actual value in user units |
| P 0282 | MPRO_FG_UsrCmdSpeed | speed command in user units | Speed command in user units |
| P 0312 | CON_CCON_VMot | actual motor voltage (rms, phase to phase) | Actual motor voltage |
| P 0410 | CON_ACT_VDC | actual DC link voltage | Actual DC link voltage |
| P 0412 | CON_PCON_ActPosition | actual position in increments | Actual position value in increments |
| P 0413 | CON_PCON_RefPosition | reference position in increments | Position reference in increments |
| P 0414 | CON_PCON_PosDiff | actual position diffence (RefPosition-ActPosition) | Difference between actual and reference position |
| P 0415 | CON_SCALC_ActSpeed | actual speed | Actual speed |
| P 0416 | CON_SCON_RefSpeed | reference speed | Reference speed |
| P 0417 | CON_SCON_SDiff | speed difference (RefSpeed-ActSpeed) | Difference between actual and reference speed |
| P 0418 | CON_SCON_RefTorque | reference torque | Torque reference |
| P 0419 | CON_SCON_ActTorque | actual torque | Actual torque |
| P 0700 | MON_CurrentRMS | actual current (r.m.s) | Actual current (mean value) |
| P 0702 | MON_State | Device status word | Status word |
| P 0703 | MON_PowerStage_TKK | Power stage temperature of cooling block | Heat sink temperature |
| P 0704 | MON_Device_Tint | Power stage temperature of interior | Interior temperature |
| P 0734 | MON_MotorTemp | motor temperature | Motor temperature |
| P 0742 | MON_UsrPosDiffHistory | monitoring maximum position difference | Position tracking error in user units |

More actual values are contained in field parameter **P 0701**

| P. no. | Parameter name Setting | Designation in DM 5 | Function |
|---|---|---|---|
| P 0701 | MON_ActValues | Monitoring, actual values of motor and inverter | Display of motor and controller actual values |
| | (0) I2xt_Motor | actual values of I2xt integrator for motor protection | Actual value of the I2xt integrator for motor protection |
| | (1) I2xt_Inverter | actual values of I2xt integrator for inverter protection | Actual value of the I²xt integrator for controller protection |
| | (2) Phasor | actual motor current amplitude | Actual value of motor current amplitude |
| | (3) Imag | actual magnetization (d-)current amplitude | Actual amplitude value of magnetizing current |
| | (4) Km | actual torque constant | Torque constant |

# Interpolation method

| P 0370 | CON_IP | Interpolation type in IP mode |
|---|---|---|
| (0) | N0Ip(0) | No Interpolation |
| (1) | Lin(1) | Linear interpolation |
| (2) | Spline_Ext_FF(2) | Interpolation with external pre-control |
| (3) | Splinell(3) | Cubic spline Interpolation |
| (4) | NonIPSpline(4) | Cubic spline approximation |

## NoIP(0): No interpolation

The values are transferred 1:1 to reference processing in 1 ms cycles.

## LIN(1): Linear interpolation

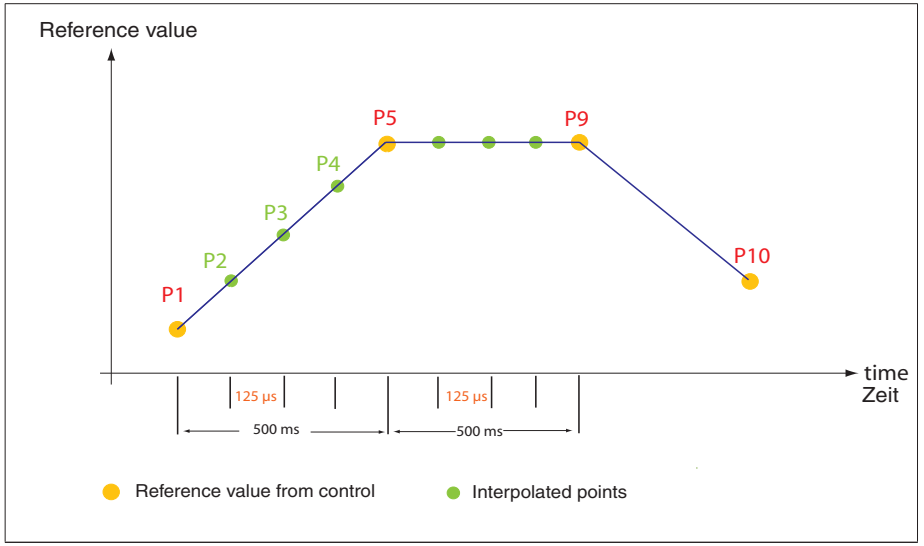



*Figure A.1 Linear interpolation*

In the linear interpolation method the acceleration between two points is generally zero. Pre-control of the acceleration values is thus not possible and speed jumps are always caused.

Application:
This method is used mainly for test purposes and for initial commissioning.

## SplineExtFF(2): Cubic spline interpolation with ext. pre-control value:

This method enables highly accurate adaptation of the position profile. The expected result should exhibit high contouring accuracy and low reference/actual value deviation.

**Application:** This method is only used from firmware version V 2.0.

## SplineII(3): Cubic Spline Interpolation:

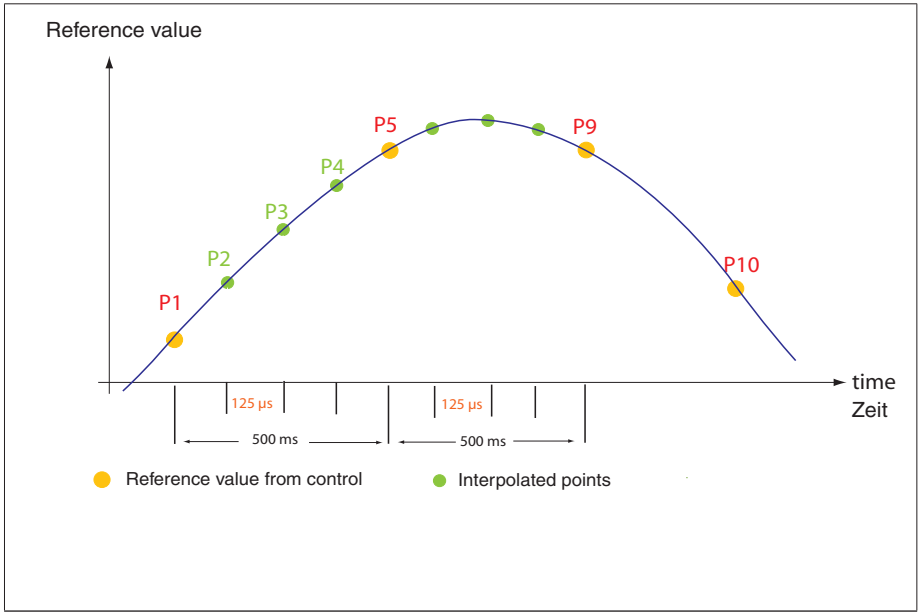



*Figure A.2 Cubic spline interpolation; P 0305=125 µs cycle*

In this method interpolation is effected between the interpolation points of the control (P1, P5, P9, P10) by means of cubic splines. The trajectory is guided precisely by the control based on the specified points. This may cause a slight jerk at those points, noticeable in the form of "noise".

Application: High contouring accuracy, slight "noise" is possible. "Noise" refers to mathematical anomalies which cannot be entirely eliminated by the computing methods applied.

## NonIPSpline(4): Cubic Spline Approximation:

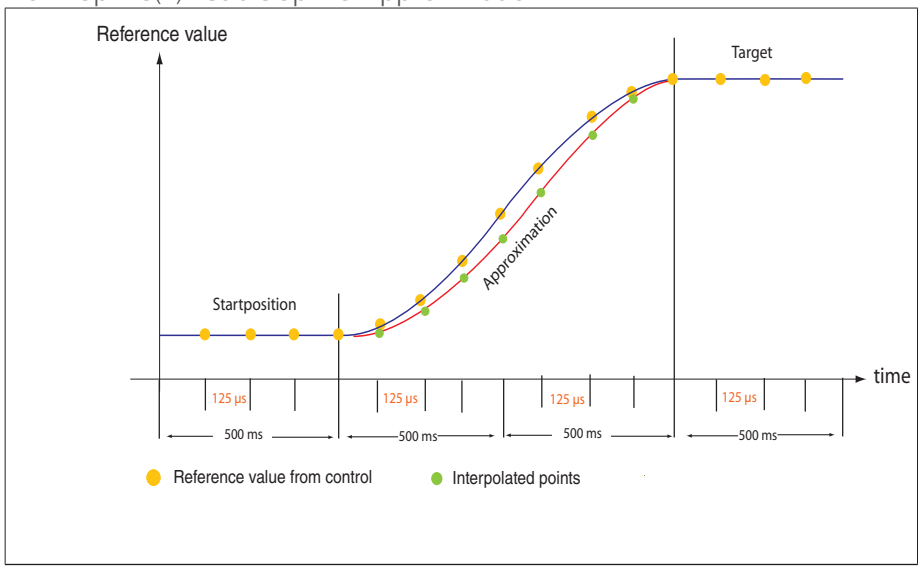



*Figure A.3 Cubic spline approximation: P 0305=125 µs cycle*

In this method the interpolation points are approximated by means of B-splines. The trajectory normally does not run exactly through the points specified by the control. The deviation is normally negligibly small. In the interpolation points the transitions are continuous with regard to acceleration, which becomes apparent by minor "noise".

In start and target position the interpolation points always match the trajectory.

Application: Minimizing noise, smoother motion, restrictions on contouring

**Note:** Further information on how to generate motion commands using the field busses or internal possibilities can be found in the field bus documentation.

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ID no.: 1100.02B.1-00 • 01/2009